ANNALS
OF
The Entomological Society of America

Volume XXXIII DECEMBER, 1940 No. 4

VERNON LYMAN KELLOGG

Professor Vernon Kellogg was a Charter Member of this Society and was a member of its first Editorial Board. He was in that small inner group of leaders to whom the Society owes its form and ideals. In 1915 he was the Society's President.

I have been requested by the Editorial Board of its Annals to give a synopsis of that earlier half of Professor Kellogg's career which was devoted to entomology. He was born in 1867 at Emporia, Kansas, into a home of books and intellectual occupations. His father was a college president earlier in life and in later years a probate judge, state senator and finally Attorney General of Kansas. Kellogg was educated at the University of Kansas where his interests were in sociology under James H. Canfield and biology under Francis H. Snow. Out of the classroom he had even greater interests. He was a leader in the many campus activities and during all vacations a camping naturalist in the nearby Rocky Mountains.

Kellogg's later education was at Cornell and in Europe at Leipzig, Paris and Florence. From 1890 to 1894 he was a Professor of Entomology at the University of Kansas and then Professor of Entomology and Lecturer in Bionomics at Leland Stanford University until he was taken into world affairs during the First World War.

Although measured in terms of years or months it is only recently that our good friend and colleague laid down his facile pen, in terms of memory it seems long indeed. It has been my good fortune to inherit, as it were, his office in Jordan Hall here at Stanford. His desk and the other furniture in the office remain as he left them. Many of the books and papers occupy the same place on the shelves and some drawers in the cabinet are still as he left them. Everything was so methodically arranged that I still cannot see another arrangement that would make things more convenient, and I realize more and more that herein lies much of the secret of his ability to do so much work.

For a striking example of his orderly method of work is the "List of Books and Papers" that he had published in 1915. This sixteen page pamphlet was issued primarily for the convenience of correspondents in effecting exchange of papers and it has served in a very helpful way as a ready reference, especially to the long list of entomological publications he had issued up to that time. Unfortunately demands on his time and energy from other sources practically ended his entomological writings during the last war. But his interest in this subject was by no means ended at that time as evidenced by his activities during his long association with the Research Council, by his private correspondence and in other ways.

There are many entomologists today, especially the younger generation who do not have access to this list or to the book published in 1939 by the Belgian American Educational Foundation in which this list is reprinted.

Dr. Kellogg's first entomological work was done at the University of Kansas with Dr. Francis H. Snow and his first entomological paper was published in the Kansas Academy of Science. Although this paper deals with the classification of the *Mallophaga* I am led to believe that his interest in this group was concerned principally with their host relationship to domestic animals. His next few papers are wholly economical as might be expected from his association with the University of Kansas where economic work was so largely stressed.

Although among entomologists Dr. Kellogg is best known for his work on *Mallophaga* and *Anoplura* he always had an abiding interest in economic entomology. Historically with the exception of the first paper on *Mallophaga* the economic papers come first, then follow various systematic and anatomical papers on various subjects, and later his important papers on variation, bionomics, and heredity. A study of this chronological list shows in a general way the development of his interest in these topics and the period of his activity in these various phases of his work.

While the War cut short his entomological writings, his later publications show the development of his greater interest in the affairs that relate more intimately to humanity.

RENNIE WILBUR DOANE.

LIST OF PUBLICATIONS IN THE FIELD OF ENTOMOLOGY

By

VERNON LYMAN KELLOGG

I. MALLOPHAGA AND ANOPLURA

Some Notes on the Mallophaga. Trans. 23rd Ann. Meet. Kas. Acad. Sci. 12: 46–48. 1890. (Brief notes on his earlier studies. No descriptions. Nitzcsh's table to genera, slightly rearranged, is given.)

New Mallophaga, I. Proc. Calif. Acad. Sci. (Ser. 2) 6: 31–168, 14 pls., March, 1896; also issued simultaneously as New Mallophaga, I, in Contrib. to Biol. from Hopkins Seaside Lab. of Stanford Univ., No. IV, 137 pp., 14 pls., March, 1896.

This and the following references are the most important contributions to this subject, serving as an introduction to the study of this group for American students. "A brief account of the structure, external and internal, of the life history and habits, and of the zoological and geographical distribution of the parasites, together with a review of the literature of the group, and a statement of the present systematic treatment of the order, with a synopsis and tables of the families and genera." This paper deals with the water and shore birds.

New Mallophaga, II. Proc. Calif. Acad. Sci. (Ser. 2) 6: 431–548, 14 pls., Nov., 1896; also issued simultaneously as New Mallophaga, II, in Contrib. to Biol. from Hopkins Seaside Lab. of Stanford Univ., No. VII, 117 pp., 14 pls., Nov., 1896. (A continuation of the above dealing with land birds with descriptions of 33 new species. Also a detailed account of the mouth parts of this order.)

The Mallophaga. Psyche 7: 375–379, May, 1896. (Notes on the group with keys to the genera.)

Mallophaga of North American Birds. Zoologischer Anzeiger 19: 121–123, 1896. Leipzig. (Brief discussion of relationships.)

A Problem in Distribution. Psyche 8: 243–247, August, 1898. (Discusses host relationship and species of Mallophaga.)

Mallophaga from Birds of Panama, Baja California, and Alaska, in New Mallophaga, III. Occ. Papers of Calif. Acad. Sci. 6: 1–52, 4 pls., Feb., 1899; also simultaneously in New Mallophaga, III. Contrib. to Biol. from Hopkins Seaside Lab. of Stanford Univ., 19: 1–52, 4 pls., Dec., 1899. (Descriptions of species from these regions.)

(With B. L. Chapman) Mallophaga from Birds of California, in New Mallophaga, III. Occ. Papers Calif. Acad. Sci. 6: 53–143, 5 pls., Feb., 1899; also simultaneously in New Mallophaga, III. Contrib. to Biol. from Hopkins Seaside Lab. of Stanford Univ., 19: 53–143, 5 pls., Feb., 1899. (Contains also an extended and useful article on the anatomy of Mallophaga.)

Some Parasites of Birds. The Auk 16: 232–236. July, 1899. (Brief descriptions of Mallophaga.)

A List of the Biting Lice (Mallophaga) Taken from Birds and Mammals of North America. Proc. U. S. Nat. Mus. 22: 39–100. 1899. (Bibliography, keys to genera, list.)

(With S. I. Kuwana) Mallophaga from Alaska Birds. Proc. Phil. Acad. Sci. 23: 151–159, 1 plate. 1900. (List and description of species, including list of hosts.)

(With B. L. Chapman) Mallophaga from Birds of the Pacific Coast of North America. Jour. N. Y. Ent. Soc. 10: 20–28, 1 pl. March, 1902. (List and notes on species, descriptions of four new species.)

Are Mallophaga Degenerate Psocids? Psyche 9: 339–343. May, 1902. (Question not definitely answered.)

(With B. L. Chapman) Mallophaga from Birds of Hawaii. Jour. N. Y. Ent. Soc. 10: 155–169, 3 pls. September, 1902. (First collection of Mallophaga, 20 species, made from these islands.)

(With S. I. Kuwana) Mallophaga from Birds of the Galapagos Islands. Proc. Wash. Acad. Sci. 4: 457–499, 4 pls. September, 1902. (Systematic account, with lists of hosts with parasites.)

Two New Genera of Mallophaga. Biol. Bull. 5: 85–91, 3 figs. July, 1903. (Analytical keys and descriptions of two new genera.)

(With B. L. Chapman) Mallophaga from Birds of the Hawaiian Islands. Fauna Hawaiiensis 3: 305–321, 1 pl. 1904. (Twenty species of which fourteen are new.)

A Giant New Biting Bird Louse. Ent. News 17: 62–63, 1 fig. February, 1906. (Description of a new species nearly 11 mm. long.)

Mallophaga from Argentine. Jour. N. Y. Ent. Soc. 14: 45–49, 1 pl. March, 1906. (Descriptions of seven new species.)

A Second Collection of Mallophaga from Birds of the Galapagos and Revillagigedo Islands and Neighboring Waters. Trans. Amer. Ent. Soc. 32: 315–324. November, 1906. (List of species and a host list.)

The Mallophagan Parasites of the Kea. Psyche 14: 122–123. December, 1907. (Notes on three described species.)

The Mallophaga of the World; Systematic Summary. Psyche 15: 11–13. February, 1908. (Lists the twenty-seven genera with the number of species in each.)

The Mallophaga of the Kilimandjaro Region. Wissenschaftliche Ergebnisse Schwed. Deutsch-Afrika Exp., Fasc. 15: 43–56, 1 pl. 1908. Upsala. (Thirty-four species of which thirteen are new.)

Mallophaga. Genera Insectorum 66, 1908. (Biology, habits, distribution. Keys to genera and list of species with references.)

Mallophaga of the Hoatzin. Zoologica (N. Y. Zool. Soc.) 1: 117–121, 1 fig. January, 1910. (Two new species described.)

Mallophagan Parasites from the California Condor. Science, N. S. 31: 33–34. January, 1910. (Lists two known species.)

(With J. H. Paine) Mallophaga from the Birds of Laysan Island. Ent. News 21: 124–125, 2 figs. March, 1910. (Eleven species of which one is new.)

(With J. H. Paine) A New Polyctenid. Ent. News 21: 401–403, 1 pl. November, 1910. (Table of genera, one new species.)

(With J. H. Paine) Mallophaga from Birds and Mammals of the Panama Canal Zone. Ent. News 21: 459–463, 1 fig. December, 1910. (Lists species one of which is new.)

(With J. H. Paine) Mallophaga from Bolivian Birds. Ent. News 22: 19–24, 3 figs. January, 1911. (List of species two of which are new.)

(With J. H. Paine) Mallophaga from California Birds. Ent. News 22: 75–79, 2 figs. February, 1911. (List of species, one new.)

(With J. H. Paine) Anoplura and Mallophaga from African Hosts. Bull. Ent. Res. 2: 145–152, 2 pls. July, 1911. (List and notes on species with descriptions of seven new species.)

(With W. M. Mann) A Third Collection of Mallophaga from Alaska Birds. Ent. News 23: 12–17, 3 figs. January, 1912. (Two new species.)

(With W. M. Mann) Mallophaga from Islands off Lower California. Ent. News 23: 56–65. February, 1912. (Five new species.)

Docophori of the Owls. Science, N. S. 37: 154–158. January, 1913. (Believes too many species described.)

Distribution and Species-forming of Ectoparasites. Amer. Nat. 47: 129–158. March, 1913. (Discusses Mallophaga in relation to their hosts.)

Ectoparasites of Monkeys, Apes and Man. Science, N. S. 38: 601–602. October, 1913. (Host distribution of parasites governed by genetic relationships of hosts.)

Ectoparasites of Mammals. Amer. Nat. 48: 257–279. May, 1914. (In effect a continuation of "Distribution and Species-forming of Ectoparasites.")

(With S. Nakayama) Mallophaga of the Vizcacha. Ent. News 25: 193–201, 1 fig., pl. VIII. May, 1914. (Three new species belonging to a new genus.)

(With S. Nakayama) A New Trichodectes from Baja California. Psyche 21: 90–92, 1 fig. June, 1914. (One new species described.)

(With J. H. Paine) Mallophaga from Birds (mostly Phasianidae and Corvidae) of India. Records of the Indian Museum 10: 217–243, 5 figs., 2 pls. 1914. Calcutta. (List of species including descriptions of twelve new species.)

Mallophaga from Birds of the South Atlantic. Science Bull. of Brooklyn Institute Art and Sci. 2: 80–89, 1 pl. November, 1914. (Lists twenty species four of which are new.)

A Fourth Mallophagan Species from the Hoatzin. Science, N. S. 41: 65–67. March, 1915. (One new species.)

(With G. F. Ferris) Anoplura and Mallophaga from Zululand. Annals of Durban Museum 1: 147–148, 2 pls. 1915. Durban, Natal. (Seven species three of which are new.)

(With G. F. Ferris) Anoplura and Mallophaga of North American Mammals. Publications of Leland Stanford Jr. University, University Series pp. 74, 8 pls. 1915. (Keys to families and genera of Anoplura, description of new species and determination of old species. Host parasitization North American Mallophaga from mammals, descriptions of new species, mammalian host list of North American Anoplura and Mallophaga.)

(With S. Nakayama) Mallophaga from the Indian Museum. Records of the Indian Museum 1: 139–140. 1915. Calcutta. (Notes on species, none new.)

(With S. Nakayama) A New Trichodectes from the Goat. Psyche 22, pp. 335, 1 fig. 1915. (One new species.)

II. Chronological List of Economic, Systematic (Other Than Mallophaga and Anoplura), Anatomical, and Other Papers Relating to Insects

1891

Insects Injuring Kansas Wheat. Rept. Kas. State Board Agric. April, 1891.

Insect Notes. Monthly Rept. Kas. State Board Agric. July, 1891.

The Chinch-bug Disease and Other Notes. Insect Life 4: 69–72. October, 1891.

1892

Common Injurious Insects of Kansas, 126 pp., 61 figs. November, 1892. Published by the State of Kansas, in edition of 10,000 for free distribution in the state.

Notes on the Elementary Comparative External Anatomy of Insects, 12 pp. 1892. Lawrence, Kas.

(With F. H. Snow) Two Grain Insects. Bull. Dept. Ent., Univ. Kas., 7 pp., 1 pl. February, 1892.

Meteorological Conditions and the Chinch-bug. First Ann. Rept. Dir. Exp. Sta. Univ. Kas., entitled Contagious Diseases of the Chinch-bug, pp. 173–191. April, 1892.

History of the Microphytous Diseases of the Chinch-bug in the United States. First Ann. Rept. Dir. Exp. Sta. Univ. Kas., entitled Contagious Diseases of the Chinch-bug, pp. 192–215. April, 1892.

Notes on *Melitera dentata* Grote. Kas. Univ. Quar. 1: 39–41, 1 pl. July, 1892.

(With L. E. Sayre) Insects Injurious to Drugs. Meyer Brothers' Druggist 13: 234–236, 20 figs. July, 1892.

Kansas Notes. Insect Life 5: 114–116. November, 1892.

1893

Insect Notes. Trans. Kas. Acad. Sci. 13: 112–115, 1 fig. 1893.

Destruction of Insects by Fungi. Trans. Calif. State Hort. Soc., pp. 29–32. 1893.

(With F. H. Snow) The Horn Fly of Cattle (*Haematobia serrata* R. D.). Bull. Dept. Ent., Univ. of Kas., pp. 5, 2 figs. May, 1893.

The Sclerites of the Head of *Danais archippus* Fab., Kas. Univ. Quar. 2: 51–57, 1 pl. October, 1893.

1894

Notes on the Elementary Comparative External Anatomy of Insects. Revised edition, 20 pp., paper cover. 1894. Lawrence, Kas.

(With F. H. Snow) A European Experiment with Insect Diseases. Third Ann. Rept. Dir. Kas. Univ. Exp. Sta., pp. 227–239. May, 1894.

The Taxonomic Value of the Scales of the Lepidoptera. Kas. Univ. Quar. 3: 45–89, 2 pls., 17 figs. July, 1894.

Insects Injuring Drugs at the University of Kansas. Insect Life 7: 31–32. September, 1894.

(With L. E. Sayre) Insects Injuring Drugs. Proc. Kas. State Phar. Assoc. for 1894, pp. 69–70. 1894.

1895

(With J. H. Comstock) The Elements of Insect Anatomy, 91 pp., 8vo., paper covers. 1895. The Comstock Publishing Co., Ithaca, N. Y.

The Classification of the Lepidoptera. American Naturalist 5: 248–257, 1 pl. March, 1895.

The Mouthparts of the Lepidoptera. American Naturalist 5: 546–556, 1 pl. June, 1895.

The Affinities of the Lepidopterous Wing. American Naturalist 5: 709–717, 10 figs. August, 1895.

(With F. J. Jack) The California Phryganidian (*Phryganidia californica* Pack.). Proc. Calif. Acad. Sci. (Ser. 2) 5: 562–570, 1 pl. September, 1895.

The Ephemeridae and Venation Nomenclature. Psyche 7: 311–315, 4 figs. December, 1895.

(With L. E. Sayre) Insects Injurious to Drugs. "Organic Materia Medica," pp. 470–478, 11 figs. 1895. Blakiston, Son & Co., Philadelphia.

1896

The Imprudent Phryganidian. Ent. News 7: 174–175. June, 1896.

Internal Anatomy of Diptera. Williston's "Manual of North American Diptera," pp. xxvi-xxviii. 1896. James T. Hathaway, New Haven, Conn.

Review of "Monograph of the Bombycine Moths of America," by A. S. Packard. Science, N. S. 4: 923–924. December, 1896.

1897

Review of Haase's "Researches on Mimicry on the Basis of a Natural Classification of the Papilionidae," trans. by Child. Science, N. S. 5, p. 228. February, 1897.

1898

Carphoxera ptelearia Riley, Herbarium Pest. Ent. News 9: 15–16. January, 1898.

The Divided Eyes of Arthropods. Zool. Anzeig. 21: 280–281. April, 1898. Leipzig.

Review of "Text-book of Entomology," by A. S. Packard. American Naturalist 32: 592–594. August, 1898.

Review of "Outdoor Studies," by J. G. Needham. American Naturalist 32, p. 786. October, 1898.

1899

(With J. H. Comstock) Elements of Insect Anatomy, 2nd ed., revised, 134 pp., 11 figs. 1899. Comstock Publishing Co., Ithaca, N. Y.

Long Life of Mosquito Larvae. Ent. News 10: 102–103. April, 1899.

Best Work in Nature Study. Western Jour. Education. May, 1899.

The Mouthparts of the Nematocerous Diptera, I–V. Psyche 8, I, pp. 303–306, January, 1899; II, pp. 327–330, 3 figs., March, 1899; III, pp. 346–348, 4 figs., April, 1899; IV, pp. 355–359, 4 figs., May, 1899; V, pp. 363–365, June, 1899, 11 figs.

Entomology in Our Schools. Proc. Calif. State Teachers' Assoc. for 1898, 3 pp. 1899.

1900

(With D. S. Jordan) Animal Life, 329 pp., 180 figs., 1900. D. Appleton & Co., N. Y.

(With O. P. Jenkins) Lessons in Nature Study, 191 pp., 82 figs., 1900. Whitaker & Ray Pub. Co., San Francisco.

Notes on the Structure and Life History of *Blepharocera capitata* Loew. Ent. News 11: 305–318, 5 figs. January, 1900.

A New Blepharocerid. Psyche 9: 39–41, 2 figs. April, 1900.

An Extraordinary New Maratime Fly. Biol. Bull. 1: 81–87, 3 figs. 1900.

Review of G. H. Carpenter's "Insects, Their Structure and Life," Science, N. S. 11: 309–310. Fenruary, 1900.

1901

Elementary Zoology. 492 pp., 172 figs. 1901. Henry Holt & Co., New York.

An Aquatic Psychodid. Ent. News 12: 46–49, 2 figs. February, 1901.

The Triangle Spider in California. Psyche 9, p. 167. February, 1901.

Food of Larvae of Simulium and Blepharocera. Psyche 9: 166–167. February, 1901.

Insects and Spiders of the Galapagos Islands. Psyche 9: 173–175. March, 1901.

The San Jose Scale in Japan. Science, N. S. 13: 383–385. March, 1901.

Phagocytosis in the Post-embryonic Development of the Diptera. American Naturalist 35: 363–368, 2 figs. May, 1901.

Studies for Students, I: The Anatomy of the Larva of the Giant Crane-fly (*Holorusia rubiginosa*). Psyche 9: 207–212, 1 fig. June, 1901.

Studies for Students, II: The Histoblasts of the Giant Crane-fly (*Holorusia rubiginosa*), Psyche 9: 246–250, 2 figs. September, 1901.

1902

Elementary Zoology, 2d edit., revised, 484 pp., 172 figs. 1902. H. Holt & Co., N. Y.

(With D. S. Jordan and H. Heath) Animals (composed of Animal Life, Jordan & Kellogg, and Animal Forms, Jordan & Heath, bound together). 1902. D. Appleton & Co., New York.

Development and Homologies of the Mouthparts of Insects. American Naturalist 36: 683–706, 26 figs. September, 1902.

O Me Faigata Ua Tutupu I Namu, a Samoan bulletin of 4 pages, concerning danger of contracting filariasis from mosquitoes; printed by London Missionary Society in Apia, 1902, and circulated in Samoan villages.

1903

First Lessons in Zoology, 363 pp., 257 figs., 1903. H. Holt & Co., New York.

(With D. S. Jordan & Heath) Animal Studies (composed of selected chapters from Animal Life, Jordan & Kellog, and Animal Forms, Jordan & Heath, and new chapters), 459 pp., 254 figs. 1903. D. Appleton & Co., New York.

The Net-winged Midges (Blepharoceridae) of North America. Proc. Calif, Acad. Sci., 3d Ser., 3: 187–232, 5 pls. February, 1903; also simultaneously as No. 30 of Contrib. to Biol. from Hopkins Seaside Lab. of Stanford Univ., No. XXX. pp. 187–232, 5 pls. February, 1903.

Studies for Students, III: Elementary Studies in Insect Histology. Psyche 10: 118–122. June, 1903.

Some Insect Reflexes. Science, N. S. 18: 693–696. November, 1903.

The Rediscovery of *Philorus* (Blepharocera) *yosemite* Osten Sacken. Psyche 10: 186–187. December, 1903.

Two Coccids from Samoa. Psyche 10, p. 187. December, 1903.

1904

(With J. H. Comstock) The Elements of Insect Anatomy, 5th ed., revised, 145 pp., 1904. Comstock Publishing Co., Ithaca, N. Y.

Parthenogenese der Moskitos. Allg. Zeitschr. für Ent. 9: 59–60. February, 1904. Neudamm.

Amitosis in the Egg Follicle Cells of Insects. Science, N. S. 19: 392–393. March, 1904.

(With R. G. Bell) Notes on Insect Bionomics. Jour. Exper. Zool. 1: 357–367. August, 1904.

(With R. G. Bell) Variations Induced in Larval, Pupal and Imaginal Stages of *Bombyx mori* by Controlled Varying Food Supply. Science, N. S. 18: 741–748. December, 1904.

(With R. G. Bell) Studies of Variation in Insects. Proc. Wash. Acad. Sci. 6: 203–332, 81 figs. December, 1904.

Regeneration in Larval Legs of Silkworms. Jour. Exper. Zool. 1: 593–599, 10 figs. December, 1904.

Influence of Primary Reproductive Organs on Secondary Sexual Characters. Jour. Exper. Zool. 1: 601–605. December, 1904.

1905

American Insects, 647 pp., 812 figs., 11 colored plates. 1905. H. Holt & Co., New York. (A London edition of this book has been issued.)

Histogenesis in Insect Development and Cell Specificity. Biol. Bull. 10: 120–121. February, 1905.

Science and the Fruit Grower. California Fruit Grower 32: 1 and 5. December, 1905.

1906

Science and the Fruit Grower. Report 31st Ann. Meet. State Fruit Growers, pp. 123–129, 1906. (Same paper as last item under 1905.)

Physiological Regeneration in Insects. Science, N. S. 23: 149–152. January, 1906.

Yellow Fever and the Panama Canal. Science, N. S. 23, p. 114. January, 1906.

Galls and Gall Flies. Nature Study Review 2: 109–114, 1 pl. March, 1906.

Colors of Butterflies and Moths. Nature Study Review 2: 206–211. September, 1906.

Is There Determinate Variation? Science, N. S. 24: 621–628, 8 figs. November, 1906.

A Note on Assortive Mating. Science, N. S. 24: 665–666. November, 1906.

Variation in Parthenogenetic Insects. Science, N. S. 24: 695–699. November, 1906.

The Growth of Insect Bionomics. Psyche 13, p. 153. December, 1906.

1907

(With D. S. Jordan) Evolution and Animal Life, 489 pp., 298 figs., 1907. D. Appleton & Co., New York.

Diptera, Family Blepharoceridae, Fasc. 56, Genera Insectorum, 15 pp., 2 pls. 1907. P. Wytsman, Brussels.

Wright's Notes on Butterfly Biology. Psyche 14: 5–8. February, 1907.

Some Silk-worm Moth Reflexes. Biol. Bull. 12: 152–154. February, 1907.

Sex Differentiation in Larval Insects. Biol. Bull. 12: 380–384, 8 figs. 1907.

Artificial Parthenogenesis in the Silkworm. Biol. Bull. 14: 15–22. December, 1907.

Insect Bionomics. Ent. News 18: 426–429. December, 1907.

Metagenesis in Insects. Science, N. S. 26: 875–876. December, 1907.

1908

American Insects, 2d ed. revised, 694 pp., 812 figs., 1908. H. Holt & Co., New York.

Insect Stories, 298 pp., many ills., 1908. H. Holt & Co., New York. (A London edition of this book has been issued.)

(With R. G. Smith) Inheritance in Silkworms, I, University Series, Leland Stanford Jr., University Pubs., 89 pp., 4 pls. 1908.

Internal Anatomy of Diptera, in Williston's "North American Diptera," pp. 49–51, 1908. Jas. T. Hathaway, New Haven.

Family Blepharoceridae, in Williston's "North American Diptera," pp. 148–152, figs. 46–47, 1908. Jas. T. Hathaway, New Haven.

1910

Luigi Bertelli's "Ciondolino," trans. by S. F. Woodruff, under the title "The Prince and His Ants"; edited, with introduction, by V. L. Kellogg, 1910. H. Holt & Co., New York.

Insect Breeding. Amer. Breeder's Mag. 1: 133–135. June, 1910.

1911

(With I. McCracken) The Animals and Man: An Elementary Text-book of Zoology and Human Physiology. 495 pp., 244 figs. 1911. H. Holt & Co., New York.

An Experiment in Double Mating. Science, N. S. 33: 783–789. May, 1911.

Insect Breeding. Sixth Rept. Amer. Breeders' Assn., pp. 98–100. 1911. (Reprinted from Amer. Breeders' Mag. 1: 133–135. June, 1910.)

1913

Butterflies of the Mountain Summits. Sierra Club Bull. 9: 85–94, 1 pl. June, 1913.

Review of Comstock's "Handbook of Nature Study." Science, N. S. 37: 669–670. May, 1913.

1914

Beetles Becoming Parasites. Science, N. S. 39: 360–361. March, 1914.

The Baby and the Bee. The Unpopular Review 1: 333–342. April, 1914.

1915

(With R. W. Doane) Economic Zoology and Entomology, 532 pp., 245 figs. March, 1915. H. Holt & Co., New York.

All of the articles, 183 in number, on Insects, in "The New Practical Reference Library," 1915. Hanson-Bellows Co., Chicago, Ill.

Collecting Insects of the Mountains. Sierra Club Bull. 9: 268–270. January, 1915.

Insects of the Pacific. Pop. Sci. Mo. 86: 265–269. March, 1915. (Also to be printed in "Nature and Science on the Pacific Coast," April, 1915. Paul Elder & Co., San Francisco.)

Spider Poison. Jour. of Parasitology 1, pp. 107–112. 1915.

Nuova The New Bee. Houghton, Mifflin Co. 1920.

STUDIES OF THE GENUS EMPOASCA
(Homoptera, Cicadellidae)

PART VII[1]

SIX NEW SPECIES OF EMPOASCA FROM MEXICO

R. H. DAVIDSON AND D. M. DELONG,
Ohio State University

Empoasca serrula n. sp.

Resembling *hecta* in shape of lateral processes and in general coloration. Length 3.5 mm.

External characters.—Vertex blunt, roundedly produced, more than twice as wide between eyes as median length. Color green, marked with orange and with spots and dashes of white. Vertex dull orange-green with a median stripe; a pair of white oblique dashes just below apex and a pair of larger whitish spots on basal portion. Pronotum dull orange green with three paler areas on anterior margin. Apical half of scutellum predominately white. Elytra with veins appearing hyaline, areas between tinged with orange. Apical veins smoky. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes rather short, tapered to pointed apices. Aedeagus concavely notched on posterior margin one-third the distance from apex, forming a definite constriction just before an enlarged head-like apex which bears an anteriorly directed pointed spur at base of head structure. Spine of ninth segment broad at base strongly concavely excavated on anterior margin and to some extent on posterior margin, forming a narrow, anteriorly curved apical portion which is serrate on posterior margin.

Holotype male, *allotype* female and a series of male and female paratypes from Guanajuato, Mexico, 11–11–27 (Dampf) and Barranca, Mexico, 11–16–26 (Dampf) and deposited in the collection of the authors.

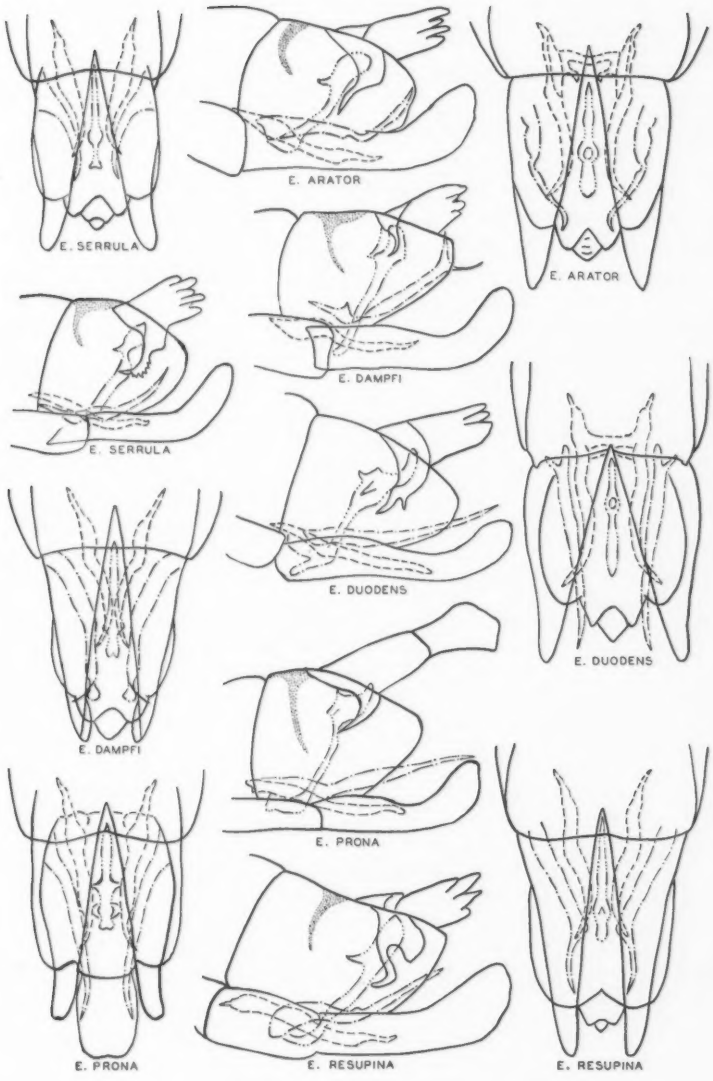
Empoasca dampfi n. sp.

A small species which in side view resembles *chelata* in shape of lateral processes. Length 3 mm.

External characters.—Vertex bluntly, roundedly produced, wider between eyes than median length. Pale in color, almost white, tinged, with green and yellow. Elytra whitish subhyaline. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes in ventral view appearing constricted just before rounded apices, a long narrow process curving outward arises at constricted portion. In lateral view the apical fourth is bent dorsally and tapered to a pointed apex and the long slender

[1]Previous parts of this study have appeared as follows: Ohio Jour. Sc., 32: 393–401; 35: 29–39; 36: 225–230; 38: 90–96; 39: 110–118, and Ann. Ent. Soc. 27: 604–609.



Ventral and lateral views of male genitalia of species of Empoasca.

caudally directed process arises at the bend. Aedeagus with apical fourth enlarged, apex broadly rounded. Spine of ninth segment small, short, narrowed at about middle to form a narrow anteriorly curved apex.

Holotype male from Mexico City, 12–14–37 (Dampf), *allotype* female from San Cristobal, Mexico, 6–19–35 (Soto), and three female paratypes from Finca Vergel, Finca Aurora, and Cocula, Mexico. Types in the collection of the authors.

Empoasca arator n. sp.

Resembling *fabalis* and *phaseola* in size and general appearance but with distinct internal male genitalia. Length 3.5 mm.

External characters.—Vertex produced about half its length before anterior margins of the eyes, blunt and rounded. Color yellowish to dull smoky with a median white line and an oblique white dash on each side of vertex. Three large white blotches on anterior margin of pronotum. Elytra subhyaline. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes directed caudally for about half their length then slightly narrowed and bent abruptly caudo-dorsally with pointed tips. Aedeagus with apical third enlarged with apex broadly curved and with an anteriorly projecting process at anterior margin of enlarged portion. Spine of ninth segment broad, directed ventrally abruptly narrowed at about two-thirds its length to form a narrowed portion on anterior-ventral margin.

Holotype male, *allotype* female, and male and female paratypes from Mexico City, Mexico (Dampf). A large series of paratypes from Rancho Monter, Orizaba, Cajeme, Finca Belem and Cacalotepec, Mexico, collected by Dr. Dampf and R. R. Soto. A small series of paratypes from Whittier, California, 4-25-40 (LaFollette) and 4-16-40 (Hiltabrand) collected from citrus. Types in the collection of the authors. Male and female paratypes in the U. S. National Museum.

Empoasca prona n. sp.

Resembling *filamenta* somewhat in shape of lateral processes but with distinctly smaller and characteristic dorsal spine. Length 3.5 mm.

External characters.—Vertex blunt, scarcely produced, wider between eyes than median length. Color yellow to green with variable white blotches and markings. Vertex usually with longitudinal white markings and with three white blotches on anterior margin of pronotum. Elytra greenish, subhyaline. Female last ventral segment appearing almost truncate, scarcely produced.

Internal male genitalia.—Lateral process long, gradually tapered to form a long narrow apical portion. Aedeagus narrow, apical fourth greatly enlarged with a broad, roundedly produced portion on dorso-caudal margin. Spine of ninth segment short, very broad at base, deeply concavely excavated on anterior margin forming a sharp pointed anteriorly directed ventral apex.

Holotype male, *allotype* female and male and female paratypes from Finca Vergel, Chiapis, Mexico, 6-7-35 (Dampf). A large series of male and female paratypes taken from the following localities in Mexico: Tamazuncharle, 11-15-38 (Caldwell); Iguala, Guerrero, 9-11-39 (DeLong); Coatepec, 8-14-34 (Dampf); Barranca, 2-16-26 (Dampf); Cuaulta, 9-25-37 (Soto); Rancho Monter, 12-14-37 (Dampf); Zoogochi, 6-22-35 (Reyer); and three specimens from Costa Rica, 5-8-10; and one from Campinas, Brazil. All types in collection of authors.

Empoasca resupina n. sp.

Resembling *duodens* in general form and appearance, with lateral processes similar to *sativae* and a characteristic dorsal spine somewhat like *ratio*. Length 3 mm.

External characters.—Vertex bluntly roundedly produced, more than half as long at middle as basal width between eyes. Color dull green, tinged with yellow and orange. Apex of vertex orange; anterior portion of pronotum with white blotches; elytra subhyaline. Female last ventral segment roundedly produced.

Internal male genitalia.—Lateral processes in ventral view abruptly narrowed at two thirds their length and broadly concavely curved to narrow pointed tips. Aedeagus broadened anteriorly on apical third with an anteriorly pointed spine at base of enlargement and with broad blunt apex. Spine of ninth segment broad with a deep rounded notch on ventral side forming a caudal rounded lobe and a narrow anterior ventrally directed portion which is bent anteriorly at apex and forms a pointed tip.

Holotype male (6-9-35), *allotype* female (5-16-35) and two paratype females from Finca Vergel, Chiapas, Mexico, collected by A. Dampf. Types deposited in collection of the authors.

Empoasca duodens n. sp.

Resembling *resupina* in general form and appearance, with lateral processes as in *prona* and a dorsal spine similar to that of *bicuspida*. Length 3.5 mm.

External characters.—Vertex bluntly produced, a little wider between eyes than median length. Color dull green tinted with orange. Elytra subhyaline.

Internal male genitalia.—Lateral processes long, straight, tapered to pointed apices. Aedeagus enlarged just beyond middle, with short heavy spines on lateral anterior margins; apical fourth concavely narrowed on anterior margin forming a thick curved, dorsally directed finger process with a rounded apex. Dorsal spine rather broad, curved anteriorly and with a pair of ventral pointed teeth, the anterior one longer and broader.

Holotype male from Huatuco, Mexico, (July, 1932) collected by A. Dampf and deposited in the collection of the authors.

THE HISTORY AND BIOLOGY OF THE JUNIPER MIDGE

(Contarinia juniperina Felt)

LEONARD HASEMAN AND S. R. MCLANE,
University of Missouri,
Columbia, Mo.

In the late fall of 1936, the junior author found an unusual amount of dead tip growth on the native red cedars in and around Kansas City, Missouri. An examination of the dead tips showed that they had been girdled or hollowed out by an insect, and during early December some of the twigs still contained the small, orange maggots which caused the injury. The litter beneath the trees and the surface two or three inches of soil were found to contain thousands of the same maggots. In the fall of 1937, and again in 1938, this same injury became worse and it then showed up throughout the state and in the adjoining states. So great was the injury at Kansas City and at Columbia that some large trees lost practically all of their tip growth, and from twenty to fifty maggots to the square inch of soil were counted under some trees in Kansas City following a cool shower on November 3, 1938.

Naturally, with such injury, this pest became a definite threat to the junipers as landscape trees and the authors immediately undertook a careful study of the pest, its identification, biology, and possible controls for it. In the early spring of 1938, adults were first reared in the laboratory at Columbia from soil and litter received from Kansas City, and in the June, 1939, issue of the Entomological News Dr. E. P. Felt described and named the gnat as a new juniper midge, *Contarinia juniperina*, n. sp.

NATURE AND EXTENT OF INJURY

The small, orange eggs are placed under the needles of the new growth near the tip of the twigs. The maggots, on hatching, bore beneath the base of the needle and tunnel out a cavity in the soft twig. In the early part of the summer the injury appears as a watery blister, but by late summer and early fall many of the twigs are severed and the tips begin to dry and bleach. A badly infested tree during the late fall turns brown, more especially on the south exposure. During the winter most of the brown tips break off, carpeting the ground. After two or three years of severe injury, most of the fine growth is removed and the trees look thin and brown with only sparse green growth.

TREES ATTACKED

The pest has been found to attack most severely our common red cedar with its horticultural varieties, *cannarti*, *schotti* and *glauca*, and the scopulorum junipers. It also attacks Greek junipers, Andorra and Savin to a less degree. It has not been found on the upright Chinese types of junipers or the pfitzers. So far, it has been found only on junipers.

DISTRIBUTION

The pest and its characteristic injury to the tip growth of native red cedars have been found widely distributed over Missouri. It has also been observed in Kansas, Nebraska, and Kentucky. Since the common red cedar is probably its natural food plant, it has, no doubt, a much wider distribution throughout the United States. It did not attract attention in Missouri until it became sufficiently abundant to do real damage to cedars, so it has probably been overlooked in other parts of the country where red cedars grow abundantly.

LIFE HISTORY

It spends the winter as a small, orange-colored maggot in the first three inches of litter and soil beneath the tree on which it developed throughout the summer and fall. In the spring the maggots pupate and begin emerging by the last of April. The pupa has the bright orange color and is nearly two millimeters long

Adult: In 1938, the small gnats with bright orange abdomens were emerging from the litter under cedar trees in perfect swarms at Kansas City on May 12. Most of the adults emerge, mate, lay their eggs, and die within a few days after heavy emergence begins, but a few may still be found on wing as late as the first days in June. The adults are not strong on wing so that, except as high winds might carry them, they cannot migrate far from where they emerge. In breeding cages, mating occurs soon after emerging and eggs are deposited during the next few days. In captivity, the adults live for only a few days. The females are heavier than the males, and they are both about 1.5 mm. long with bright orange abdomens.

Egg: The small, orange eggs placed beneath the base of the needles are oval, about one-fourth millimeter in length, and one-fourth that in diameter. They are smaller and less oblong than eggs of the hessian fly. The incubation period under cool, outdoor conditions has not been determined, but in the laboratory they seem to hatch in about a week. On hatching, the small larva seems to bore down between the base of the needle and the twig and later forms a yellowish blister involving the base of the needle.

Larva: The orange color found in all stages of development, due, no doubt, to the food, becomes very intense in the older larvae. On hatching, the larva is about the same size as the egg and on maturing and leaving the twig it is from two to two and one-half millimeters long and one-third as wide. It is somewhat flattened. The eggs hatch in May and by August 20 the larvae are still very small, their presence being indicated by a slight discoloring or formation of a blister at the base of the needle. On September 14, some larvae were found

apparently nearly full-fed, while others were still not over half-grown. At that time the infested twigs were beginning to show yellowish areas on the surface, but the tips of the twigs were still green and severe girdling by the larva had not yet occurred. Some typical dead tips were observed, however, without any larvae in them. By October 10, in 1939, full-grown larvae were found in abundance at Kansas City. From one to five larvae were found in a twig. At that time, the scopulorums were much more severely infested than the red cedars. Larvae were still present in goodly numbers on November 15. In fact, a few mature live larvae may be taken in the twigs any time in the winter or even in the spring. There is only one generation a year, the larvae requiring from May to October or later to become full-fed, when they may drop from the twigs in perfect showers, going into the ground for the winter.

NATURAL ENEMIES

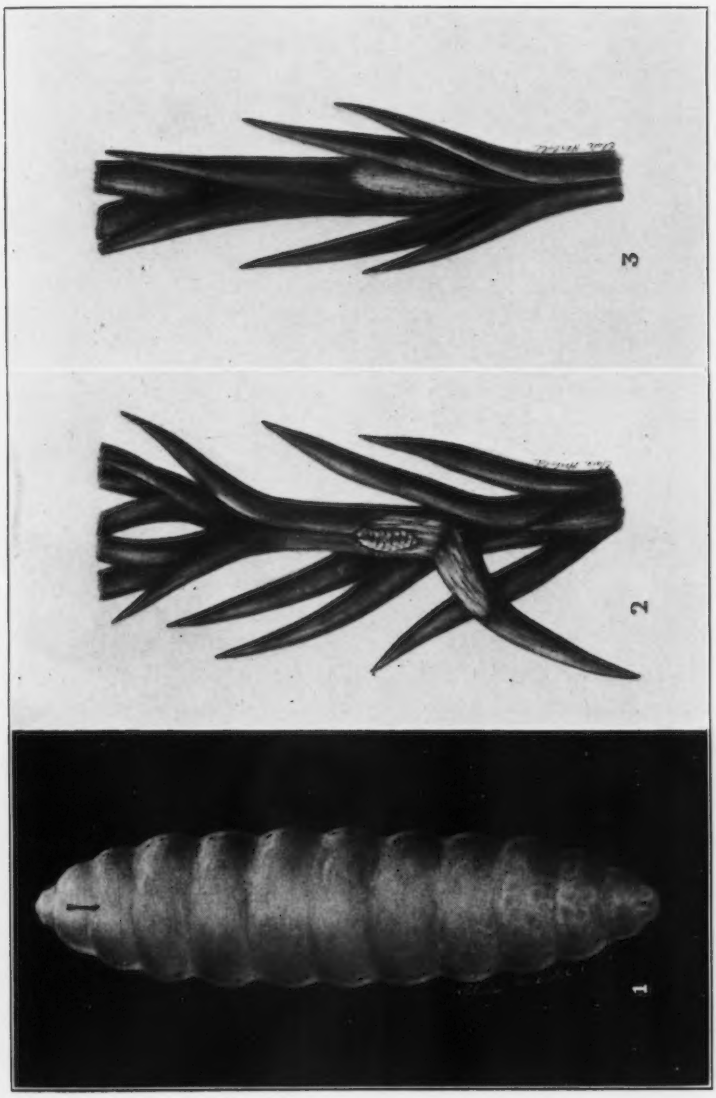
The juniper midge is one of those insects which, when conditions are favorable, may develop in numbers sufficient to seriously damage their host plant. In the last three years, they have practically killed a number of large, healthy red cedars. It seems to be definitely affected by unfavorable weather conditions, especially as the adults are emerging and laying eggs in the spring. Prolonged cold rains definitely reduce their numbers and the number of eggs laid. However, cold rains lasting only a few days in 1938 did not prevent them from producing a heavy brood of larvae that summer. Normal winter cold does not seem to harm them and prolonged high summer temperatures do not seem to affect them.

Their one effective natural check is a small, black, hymenopterous parasite which attacks the larvae in the soil in the spring just before they pupate. The parasites begin emerging in the breeding jars a few days before the first adult midges appear and they continue to emerge along with them for two weeks or more. This parasite has been determined by C. F. W. Muesebeck as *Platygaster pini* Fouts, and it is a very effective check on the pest. In 1937, a great many of the parasites appeared in our breeding jars. In 1938, there were about as many parasites as midges. In 1939, breeding material from both Kansas City and Columbia gave a large predominance of parasites over midges, and the 1939 brood of larvae has been almost wiped out on many trees. Trees with most of their tip growth killed in the fall of 1938 are now almost free of dead tips, due, undoubtedly, largely to the effects of this small parasite. On the other hand, some trees in Kansas City had 90 per cent of their tip growth killed this fall. Over most of the area of heavy infestation since 1937 the pest seems to be on the wane and it is hoped that the little parasite will be able to place it under complete control.

EXPLANATION OF PLATE I

Contarinia juniperina Felt, the Juniper Midge

Fig. 1. Larva, ventral view. 2. Larva burrowing in cedar.
3. Gall of the Juniper Midge larva.


3
2
1

CO-OPERATIVE NEST-FOUNDING BY THE WASP, POLISTES ANNULARIS LINN.

PHIL RAU,
549 East Argonne Drive,
Kirkwood, Mo.

I have on several occasions recorded the behavior of queen *annularis* wasps when they come out of hibernation in the spring and prepare to found new nests. They hibernate some distance from the home in which they spent their infancy and early adulthood, but usually fly back to the nest and visit it again and again on warm days in spring, later congregating and remaining on it for several days. Then in small groups they fly to nearby trees and commence their new nests.[1] In addition to this well known method of co-operative colony-founding, I have observed, in the spring of 1940, that as the nest increases in size, other queens attach themselves to the colony and help the original foundresses carry on the work. By marking wasps with drops of paint, the following facts were gathered on a colony at Pacific, Missouri. In a low farm building, on May 1, I found a ten-cell nest of this species with two queens; six feet away was another Annularis queen just commencing her nest, while in a crack in the wall a little distance away, was an aggregation of three Annularis queens huddled close together. Near a window eight feet away was a large last year's nest of this species, which evidently gave birth to all the queens now under observation. The temperature during the day had dropped to 38 degrees F., and all the queens were in a sluggish condition and did not leave the nests.

The wasps were not again examined until a month later, when I was surprised to find on the nest with ten cells, not two queens, but seven. In addition to the two original foundresses, I found one with a white mark, which branded her as one of the company of three that had sought shelter in the crevice, and also four without marks whose previous history was not known. During the month the nest had grown in size, and now had 110 shallow cells which indicated that all of the adults must have done much work to bring it to this stage, and it proved also that the newcomers were not, as I had at first suspected,

[1]Bull. Brook. Ent. Soc. 23: 230–235, 1928; Ann. Ent. Soc. Amer. 23: 461–466, 1930; Psyche 38: 129–144, 1931; Ecology 10: 191–200, 1929.

merely cockoo-bird wasps that came for the purpose of depositing their eggs in the nests of their industrious sisters. All of the adults were queens and could not have hatched from this nest, since none of the cells were large enough to have harbored them. In observing all seven wasps for several hours that afternoon, I found that all of them shared in the work, the five new ones bringing in food and pulp and the two original foundresses remaining on the nest to receive it, often greeting an incoming wasp with an antennal caress or with mouth to mouth contact in the solicitation of nectar.[2] With 110 cells filled with eggs and larvae it is quite likely that all seven queens had a part in producing them;[3] by way of comparison I might mention that the *annularis* nest with the one queen which was begun a month ago, now contained only 13 cells with eggs or small larvae.

My next visit was ten days later (June 10) and I again found a change in the personnel of the colony. None of the young in the cells had thus far become mature but three of the larvae had spun cocoons. One of the two original queens, and also one of the unmarked four, had completely disappeared during this period; however, in their stead I found three new queens, two of which were unmarked (and had come from unknown sources) and one bearing the mark which proved her to be the queen of the nearby 13-cell nest. The latter had deserted her home and young; her nest was still in its place, but the abandoned larvae were dead and discolored. There were now eight queens on the nest, all of whom were busy all afternoon bringing in pulp and food; and the original foundress herself was seen to bring in loads of pulp and apply them to unfinished cells. So busy were they, that often most of the wasps were abroad at one time, leaving sometimes only one at home to guard the nest. There was little wonder for all this activity now, because there were many mouths to feed in the 110 cells.

To summarize then, one sees that the original swarm of queens which co-operatively founded the nest, also permitted, from time to time, other queens without nests—or lonely ones

[2]On this visit it seemed that the newly adopted wasps assumed the role of workers, but on a visit a few days later I found that the one remaining foundress at that time, also went abroad and brought in pulp.

[3]I may also mention that after the conclusion of the work on June 10, three of the queens (one of the original foundresses and two late comers) were dissected and eggs were found in all of the abdomens.

which have singly founded nests—to attach themselves to the colony. Single queens of *annularis* evidently suffer much from loneliness, for the whole of their lives is spent in the company of others of their species; the juvenile, adolescent, and hibernating stages are spent in large or small aggregations, and the founding of new nests is usually done co-operatively, and after the first workers arrive, the queens are part of a large colony on the nest. Therefore one may legitimately suspect that a single queen on a nest, or one without a nest, is miserable in her loneliness and loses no opportunity to procure the company of others. *Polistes pallipes* in this region, on the other hand, do not build nests co-operatively, and usually only one queen is foundress of the nest; still on rare occasions a lonely queen of *pallipes* abandons her offspring and attaches herself to a nearby nest, whose friendly queen welcomes her (Bull. Brook. Ent. Soc. 33: 230–231, 1938), although on some occasions the impostor is repulsed and driven away. (Bull. Brook. Ent. Soc. 23: 234, 1928). The etiquette of nest appropriation in *pallipes* is rather loosely adhered to, however, for on one occasion when queen *pallipes* from several nests were lost in homing experiments, other queens soon came along and adopted the nests and young.

With so little regard for property rights among Polistes queens, one may readily see how the colony, from the standpoint of the scientist, may easily become the mark for biological complications. It was at first thought that the three nestless wasps in the crevice were individuals that had not been fertilized the year before and therefore were not able to found nests of their own, but the fact that one queen with a 13-cell nest was willing to abandon it and attach herself to an active colony, militates against the idea that it is only the impotent or the virgin queens which attach themselves to growing colonies of sister wasps. Again, it was thought that when lonely queens attach themselves to the nests of other wasps—or what is still more important, when several queens co-operatively found a nest—we have a condition which is nearly akin to that which is known in the insect world as Social Parasitism. But we must not lose sight of the fact that social parasitism as we know it, for example, in the *Bombus-Psithyrus* complex (where the Bombus queen is murdered and her progeny become slaves to the young of Psithyrus) is greatly different from the founding of an *annularis* colony—where all the queens share alike in nest-building, in egg-laying, as well as in feeding one another's larvae.

It is, as I have said, a far reach from the nesting habits of *annularis* to the behavior of social parasites such as the Psithyrus bees—and yet one must not forget that Psithyrus which now prey upon bumblebees were, at a time not so very remote, once themselves bumblebees. Today, we find that Psithyrus in behavior, in structure and in physiology, has strayed far, indeed, from the fold of her ancestors; even to the point of entirely dispensing with the worker-caste; in spite of all this she still bears, however, many of the marks of her bumblebee ancestry. Perhaps it may not be amiss to suspect that one big step in the species long sweep of evolution from Bombus to Psithyrus was a stage very much like that which we see in colonies of *annularis* today—a number of sister queens using a common nest as a receptacle for the offspring of all, with all of them sharing in the work and in the care of the brood.

Perhaps, also, it may not be amiss to further suspect that at a future time some of the best "minds" among *annularis* queens will learn that it is possible to deposit eggs in nests made by others, and leave the care and the feeding of their young, in cuckoo-bird fashion, to the labor of others. It seems to me that the mingling of several queens on a nest, may easily give rise to social-parasitism, for the conditions—as well as the opportunities—are at hand to encourage labor-shirking mothers to surreptitiously lay eggs in nests made by sister-wasps, and thus give origin to a trait which may perpetuate itself in heredity. How long will it be, one wonders, before an offshot from the stem of Annularis will give rise to a relationship analogous to the Bombus-Psithyrus complex?[4] At any rate, further study of these problems, difficult as they are, is well worth much time and thought, for nowhere else in the insect world—outside of a few genera in the family Vespidae—do we find just this kind of co-operative nestfounding.

[4]For excellent studies in Social Parasitism see Wheeler, "Social Insects," Chap. 11, 1928, and Wheeler, "The Parasitic Aculeata, A Study in Evolution," Amer. Phil. Soc. 58: 1–40, 1919.

ON "TYPE" SPECIMENS

C. B. Williams,
Chief Entomologist,
Rothamsted Experimental Station,
Harpenden, England

Mr. H. T. Fernald's paper "On Type Nomenclature" in the December, 1939, number of the Annals of the Entomological Society of America (Vol. 33, p. 689) draws attention to the absurdity to which a useful conception can be carried, and indicates a confusion of thought in the entomological world which seems to call for comment.[1]

These comments can be divided into three headings:

(1) What is the use of a "type" specimen.

(2) Need a "type" specimen be typical.

(3) Could a better term than "type" be found.

(1) If a description of a new species could be made so perfect that it exactly described the differences between this species and all others, known or yet unknown, the description would be as good as a specimen for purposes of identification and reference to the specimen would be unnecessary. Needless to say this cannot be done.

If the exact limits of a species were beyond dispute, if everyone knew where varieties, races and all forms of continuous variation and polymorphism ended and where a new species began—if in fact species were really the old fashioned conception of pigeon holes sharply divided from each other—then type specimens would be unnecessary, for any other specimen of the species would be equally valid for comparison. This also is unattainable.

The designation of a particular specimen as "type" adds nothing to our scientific knowledge. It is a mechanical device, like a card index or a library catalogue to assist us in finding and arranging our knowledge with the least possible trouble.

The value of a "type" specimen comes in when there has been insufficient knowledge, producing doubt or mistakes in identification. If at any time it is thought or proved that two species

[1]This is not a criticism of Professor Fernald as I understand he feels as I do about the matter.

have been confused under one name, then the "type" is a dodge to determine without further dispute to which of the two divisions the original name will now apply. The "type" has nothing to say on the truth or otherwise of the supposed limits of the species, but it is the final court of appeal for purposes of nomenclature only, and the whole value of the type depends on the fact that there is "no possible probable manner of doubt" about it.

If the truth of this be granted there can be no possible probable manner of reason for having any other type except a single one for each species name. The object of the type is to eliminate from nomenclature the possibility of human error, the personal equation, and private opinion and this object is defeated if more than one type is designated. As soon as a second specimen appears opinion is brought in. If I designate "cotypes" or "paratypes," or any of the hundred or so others listed by Fernald, I imply my belief that these specimens are co-specific with the type. My opinion may be sound or unsound, but it is an opinion. If I am careless, one of my "paratypes" may be of less value for comparison than specimens compared with my type by a more careful worker. Furthermore, the "opinion" expressed as to the fact that co-types are of the same species as the type is a scientific opinion and not a nomenclatorial problem.

Perhaps the most dangerous of all in introducing opinion is the designation of "type" specimens of the opposite sex, or of an immature stage. This serves neither scientific nor nomenclatorial purposes. Either the specimen so designated does or does not belong to the same species as the original "type." If it does, no question of nomenclature arises; if it does not, an error has been made, the effects of which are only accentuated by introducing nomenclatorial complications.

By the above I do not wish to imply that the information that a particular specimen has been compared with the type—or comes from the same locality as the type—or was with the type at the time of original description—is not of interest. It is on the contrary of great interest, but scientific and not nomenclatorial. As long as the original single "type" exists, such specimens as these can never be the final argument for nomenclature. Always in them is expressed the scientific opinion of the limits of a species and hence the possibility of uncertainty.

(2) The definition of "typical" as referring to a "specimen with characters corresponding to those of the type material" (Fernald, l. c., p. 701) is incorrect and misleading. The term "typical" has a scientific meaning implying normality. The "type" specimen may or may not be typical. If the describer has only a single specimen he has no means of knowing if it is typical or not. If he has long and variable series available it would be better for him to choose as "type" a specimen definitely towards one end of the series rather than a more "typical" one in the middle. The type specimen is only of importance if it should be found that two species have been confused under one name. If such a division has at any time to be made in a long and variable series of individuals originally thought to be one species, then it will be simpler if the "type" specimen is near one end of the series than near the dividing line in the middle when doubt might occur as to which side it belonged. The object of the type specimen is to remove all cause for argument, and anything that will aid this must be acted on.

(3) The term "type" has the unfortunate association with the word "typical," but the type is typical of nothing. It is only an indication of which groups of individuals must be associated with a particular specific name. It is not scientific but technique. It is unlikely that the word and its hundred odd compounds will ever now be given up, but it has happened to me for many years that the word "Index" specimen would convey much more clearly the object of the technique, and would get away from the mistaken association with the implications of the word typical.

I sincerely hope, however, that no one adopting it will immediately double the confusion of the present absurd position by starting a new series of "Allaparalect index" and "Proto plastindex," etc. For each specific name there must be only *one* "index" specimen and only if this is destroyed does any case exist for a new designation. If this should be done, however, it must be recognized that human opinion and hence doubt has been introduced by the implied idea that the new specimen is co-specific with the old.

Incidentally I can find no word in Fernald's list for a photograph of a cast of an abnormal larva of a worker of a social hymenopteron, which has been compared with specimens from the same locality as the type. It should, I believe, be:

"Photo-plasto-terato-nepiono-ergato-homotopo-type,"
but perhaps I am wrong. In any case I would insist that though such material might be of considerable scientific interest, it would be of no final value in questions of nomenclature.

SUMMARY OF CONCLUSIONS

(1) The object of a "type" specimen is to have a guide, for nomenclatorial purposes only, which is free from personal opinion and hence above dispute. Only a single specimen can have such a status.

(2) There is no connection between "type" specimen and "typical." The former is a nomenclatorial dodge, the latter the expression of a scientific opinion.

(3) In choosing a type specimen from a varying series (which, of course, means from any series) it is better to choose an individual of extreme form rather than a "mean" or "typical" specimen.

(4) I suggest that the word "Index" specimen, as one which *indicates* the nomenclature, would be a better designation than "Type" specimen.

Addendum.—On further consideration I have come to the conclusion that the word "Nominal" would be an even better description for the specimens in question than the word "Index," that I have suggested above. It is directly derived from the word "Nomen" or name and emphasizes the purely nominal value of the specimen.

PERSONAL BIBLIOGRAPHIES

Under this head we will be glad to list personal bibliographies of members of this society. They must be in some printed form such as mimeograph, lithoprint, photolith, planograph or some similar process or actually printed. They must be available from the author on request.

We believe a development of this type of bibliographic service can be of considerable value. Our copies of personal bibliographies sent for notice in the Annals are deposited in the Ohio State University Library, Botany and Zoology Division. We list:

"Publications" of Harvey L. Sweetman, in entomology, Dept. of Entomology and Zoology, Massachusetts State College, Amherst, Mass. 1925–1940. Mimeograph.

"List of Publications" of C. T. Brues in entomology, Biological Laboratories, Harvard University, Cambridge, Mass. 1900–1940. Mimeograph.

COMMENTS ON C. B. WILLIAMS' PAPER, "ON 'TYPE' SPECIMENS"

H. T. FERNALD,
Winter Park, Fla.

The editor of the "Annals" has very kindly sent me Dr. Williams' paper (at the suggestion of the latter) for comment in case I might care to do so.

I am in entire agreement with this paper except on two points. I feel that the present status of type nomenclature for species is most unsatisfactory and can easily (as I tried to point out in my article: Ann. Ent. Soc. Am. 33: 689–702) become so confused as to be useless. That the time has come to call a halt in the production of more such terms and to systematize and rearrange those we have already been afflicted with and eliminate the synonyms.

Most of the terms, as Dr. Williams points out, could very comfortably be done away with, but I doubt if all could be eliminated to advantage.

The real value of "Type" or better, "Holotype," as I see it is where a description of a species is so poor, incomplete, or so lacking in the characters which distinguish it from allied species that a student of the group cannot tell what insect is meant. This condition is naturally the case with many of the older descriptions and the only way of finding out now, what insects these really refer to is by an examination of the specimens from which the descriptions were made. This seems to be conceded by Dr. Williams. But if this is true for holotypes it should be equally true for the allotypes, at least where these do not closely resemble their holotypes, for the day of poor descriptions is not yet over.

As to the list of terms itself I must call attention to the fact that it is a list of the names which have already been proposed by one writer or another. In this connection it might be noted that Dr. Williams has in this paper actually named and defined another to add to it, viz.: "Photo-plasto-terato-nepiono-ergato-homotopo-type"!

While it might be desirable, perhaps, to substitute some other word or suffix for "type" to use in connection with these names, I doubt if "Index" or "Nominal" would be accepted by entomologists, zoologists or paleontologists at large. Its use has been continued too long for such a change to be generally adopted.

PALAEMNEMA JOANETTA A NEW DRAGONFLY FROM PANAMA (PLATYSTICTIDAE: ODONATA)

CLARENCE HAMILTON KENNEDY,
The Ohio State University,
Columbus, Ohio

A brownish black species with clear wings, a bluish stripe across the face, anterior lobe of prothorax largely blue, two lateral blue stripes on metathorax and the dorsum each of abdominal segments 8–10 pale blue.

Male, abdomen, including appendages, 33.5 mm.; hind wing, 22.0 mm. long. Described from the single male holotype collected by Dr. S. W. Frost on the Upper Indio River, Panama, December 28, 1936, and at present in my collection.

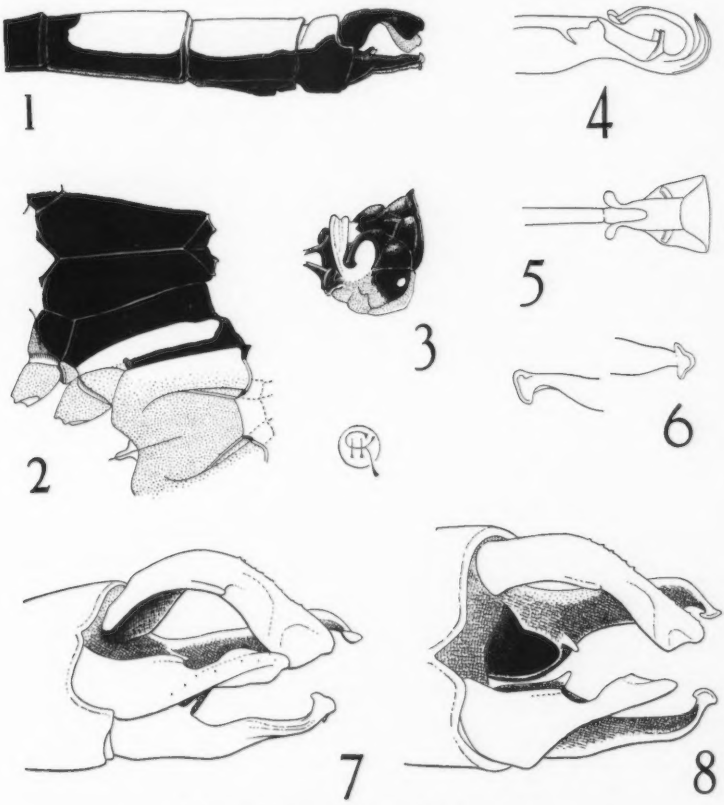
Joanetta = Janet (little Joan). Named for my daughter, Mary Janet Kennedy.

Holotype male.—Ground color of head black; labium pale across base darker towards apical edge; lower two-fifths of labrum jet black, as are its lateral edges; upper three-fifths and anteclypeus a creamy white with bluish reflections; lateral edges of anteclypeus and post-clypeus black: bases of mandibles and adjacent genae bluish. Antennae dark brown, remainder of head jet black. (Head lost after description.)

Prothorax with dorsal surface black, except anterior lobe blue which color extends along middorsal line as a blue triangle with notched apex on anterior part of middle lobe: also each side of middle lobe with an oval blue spot and a minute blue speck as in fig. 3. Proepisternum pale, proepimeron clouded with dark brown, lighter cephalad and ventrad. Coxae pale yellow. A narrow black spot on middle line of sternum. Prothoracic legs missing. Meso-metathorax with dorsal surface (mesepisternum) largely black, except for a pale brown area in each outer angle of mesostigmal lamina. Mesepimeron dark brown, this shade extending over humeral suture as a narrow edge along mesepisternum. Mesinfraepisternum dark brown; middle coxae pale. Metepisternum with a broad pale blue stripe covering its anterior or dorsal two thirds; this stripe rounded below the alar carina and fading into pale yellow in region of metathoracic spiracle; the posterior third of metepisternum a dark brown stripe. Metepimeron in general yellowish but with its posterior third showing pale bluish shades. (Probably in life this is a second lateral blue stripe as shown in fig. 2.) A triangular black speck between middle coxae but remainder of ventral surface yellow. The single hind leg pale with a darker stripe on outer surface of femur; apex of femur dark. Wings clear; stigmas black.

Abdomen with segment 1 yellow on sides and below, dark brown on upper half and dorsum. An oval black "ear" on apical edge on lower side. Seg. 2 with upper half of sides and dorsum dark brown, a broad

yellow stripe along lower side which does not reach base of segment. Segs. 3–6 dark brown shading into black caudad, with a narrow pale basal ring on each. Seg. 7 black. Segs. 8–10 black on sides and across basal sixth of seg. 8 but dorsum otherwise pale blue and ventor of 8 and 9 pale brown; appendages black.



Palaemnema joanetta n. sp., holotype male.

Fig. 1. Abdominal segments 8–10. 2. Thoracic color pattern (dark brown and black are treated as black). 3. Prothorax (unstippled white indicates pale blue). 4, 5. Penis. 6. Apices, left and right, of inferior apical appendages. 7, 8. Apical appendages of abdomen.

Structural notes. Postnodals, fore wings, 15 and 14, hind wings, 11 and 11; M_2 arising at level of postnodal 5 in each fore wing and at level of 4 in each hind wing. Apex of Cu_1 under postnodal 4 in each fore wing, at 7 in one hind wing and at 8 in the other.

The penis (figs. 4-5) has simple oval apical filaments. In Calvert's key (1931) this species falls in the first section with dark propleuron, segs. 8 and 9 blue, metepimeron with no brown or longitudinal stripe (CC p. 26). This groups *joanetta* with *mutans*, *peruviana*, *melanostigma* and *gigantula*. However, the above is largely in color. In structure of appendages and also color except the pale dorsum of 8, 9 and 10, it fits better in the next group (BB, p. 27) with *mutans*, *brucei*, (*brucelli* Kennedy. and *martini* Cowley.) It differs from *mutans* in having no humeral blue stripe or spot, in having a distinct triangular cap on apex of inferior appendages, in having a strong basal spine on inferiors and in having a very shallow excision in apex of superior appendage, in having a black stigma (in *mutans* ox-blood red). A longer series from Panama may tie *joanetta* into *mutans* Calvert.

LITERATURE

Calvert, P. P. 1931. The generic characteristics and the species of Palaemnema (Odonata: Agrionidae). Trans. Amer. Ent. Soc. 57 (No. 950): 1–110, 2 text figs., 21 pls.

Cowley, J. 1934. Notes on Platystictidae (Odonata) of the Neotropical Region. Stylops 3(9): 201–204, 12 figs.

Kennedy, C. H. 1938. *Palaemnema picicaudata*, *P. abbreviata* and *P. brucelli*, new dragonflies from Ecuador, with notes on other Palaemnemas (Odonata: Platystictidae). Ann. Ent. Soc. Amer. 31(2): 249–266, 48 text figs.

BRITISH BLOOD-SUCKING FLIES. By F. W. Edwards, H. Oldroyd, and J. Smart. viii + 156 pp., 45 pls., 64 figs. Printed by the British Museum, 1939. London, S. W. 7. Price, 15 shillings.

In 1906 E. E. Austen wrote a book on the blood-sucking flies of Britain. The edition was soon exhausted and since then a second one was in preparation. Many duties, however, prevented Major Austen from getting the manuscript in shape and after his death the task was assumed by Edwards, Oldroyd, and Smart who treat, respectively, the Nematocerca, Brachycerca, and Cyclorrhapha.

The second edition has the same aim and plan as the first. In non-technical fashion precise information is given on the habits, life-history, and distribution in Britain of every species of blood-sucking fly known to occur there. Short descriptions and illustrations permit ready identification of each species. Notes on damage caused by flies and the transmission of diseases by them are included. Two appendices deal with the genitalia of British Culicoides and a discussion of gadding and the flies which incite this behavior.

This book brings to light many isolated facts buried in a vast literature. It integrates the contributions of past workers and serves a very important function of directing future research by pointing out gaps, particularly in behavior and life-histories, which must be filled for a proper understanding of the species involved. Seven new species of Culicoides are described and the section dealing with the genitalia of British forms furnished much of the data for a proper evaluation of the British fauna. A total of 119 species of Diptera is considered and a number of these species, especially Culicidae and Simulidae, occur in the United States.

The illustrations are excellent and all but one of the plates are colored. Dried museum specimens were used by the artist, hence the brilliant coloration of some things, such as the eyes of certain horseflies, is lacking. The text figures deal primarily with the wings and genitalia of the Ceratopogonidae and the heads of Tabanidae. In keeping with the beautiful illustrations the construction of the entire book is of very high quality and uniform with related publications of the museum.—C. V.

A REVISION OF THE EMBIOPTERA OF NORTH AMERICA[1]

EDWARD S. ROSS[2]

California Academy of Sciences,[3] Golden Gate Park, San Francisco, Calif.

The Embioptera constitutes one of the smallest and most unique orders of insects. It exhibits a number of unparalleled specializations as well as certain primitive features which suggest a great antiquity. In this connection Imms (1913) makes the following interesting statement: "That the Embiidae are an ancient group, and now long past the zenith of their prime is probable. In this respect they are worthy of comparison with *Peripatus* and *Anaspides* among other Arthropods."

A number of schools of opinion prevail regarding the phylogenetic position of the order. One led by Tillyard, using wing-venation and paleontological evidence, places the order near the Plecoptera. Another, including Snodgrass (1937, male genitalia), Kershaw (1914, embryology) and others, strongly believe it to be an orthopteroid group. Mukerji (1927) suggests that the members of the order are the only surviving representatives of the Protorthoptera.

The group is for the most part restricted to the tropics and subtropics but extensions of range into the warm temperate zones occur. In the northern hemisphere it reached 45° latitude in the Crimean region of the Old World, but in the

[1]America north of the Isthmus of Tehuantepec and including the Greater Antilles.

[2]The writer is indebted to the following individuals who either arranged loans of material from their respective institutions or placed their personal collections at my disposal: A. B. Gurney, U. S. National Museum; Nathan Banks, Museum of Comparative Zoology; E. P. Van Duzee, California Academy of Sciences; W. D. Pierce, Los Angeles County Museum; R. H. Beamer, Snow Museum, Kansas; W. J. Gertsch, American Museum of Natural History; P. B. Babiy, Cornell University; R. A. Flock, University of Arizona; H. G. Rodeck, University of Colorado; O. L. Cartwright, Clemson College, S. C.; P. H. Timberlake and P. DeBach, Citrus Experiment Station, Riverside, Calif.; P. C. Ting, State Department of Agriculture, San Francisco, Calif.; C. H. Seevers; W. E. Simonds; G. E. and R. M. Bohart; L. Gillogly; I. Moore; E. C. Van Dyke; N. Stahler; J. L. Gressitt.

Thanks are also extended to E. G. Linsley, E. O. Essig, C. D. Michener, T. D. A. Cockerell, G. F. Ferris and M. A. Cazier for other assistance.

I owe special gratitude to Mr. Consett Davis of New England University College, N. S. W., Australia, with whom, at the time of his stay at the University of California, I enjoyed many lengthy discussions on the taxonomic problems of the order and later a continuous exchange of correspondence concerning our respective work.

[3]This research was largely conducted in the Division of Entomology of the University of California, Berkeley.

New World it is known to occur only up to about 40° in Northern California. In the Southern Hemisphere extensions to about 43° south-latitude are recorded from Tasmania.

The species, although generally remarkably distinct from one another, have many morphological and biological features in common. Perhaps the most important of these is the presence of silk-glands in the basitarsi of the fore-legs which are used to produce the silken galleries in which they live. The ability to produce such galleries has probably been the greatest single influencing factor in the subsequent evolutionary trends of the order. The fact that these glands are possessed by even the most morphologically-divergent species throughout the range of the order and by both sexes and all instars, seems to indicate a great antiquity for this function.

The only other insects known to possess silk-producing glands in such a position are certain flies of the family Empididae (Eltringham and Hamm, 1928). The glands in this case are, however, quite distinct from those of the Embioptera and the silk produced is used for entirely different purposes.

Another peculiarity, likewise universal in the order, is the unique musculature of the somewhat saltatorial-appearing hind femora. The depressor muscle of the tibia, not the levator (as in the Saltatoria, etc.), is greatly developed and occupies most of the volume of the swollen femur. This is undoubtedly correlated with the habit of running rapidly in reverse (also see Davis, 1938, p. 271).

The adults are generally highly sexually dimorphic. The females, as far as known, are all apterous as a result of neoteny whereas the males of the majority of species are winged possessing two pairs of slender subequal wings with highly specialized venation. When at rest these are compactly laid over the dorsum of the pterothorax and most or all of the abdomen much in the same manner as in the Isoptera and Plecoptera. These do not interfere with forward movements in the narrow tunnels, but when the insect darts backward, the wings are a definite hinderance. The friction with the opposing wall of the tunnel causes them to fold or crumble forward over the head[4] and thus may retard escape from enemies. Elimina-

[4]The great flexibility of the wings suggests the question of how such wings are able to support the insect in flight. The writer's observations thus far indicate that they are held rigid by blood pressure in the very large, hollow radial vein (R_1) which is practically closed distally. In an expanded wing of a live individual the haemocytes in this vein were seen to advance and retreat short distances with each beat of the heart but not to progress toward the terminus.

tion of wings, for this reason, by selection, may be the explanation of their universal loss in the female as well as the same tendency in the male. In many species (i. e., *Anisembia* Krauss) and even the whole genera (i. e., *Metoligotoma* Davis of Australia) winged males are entirely unknown, while in at least three species, *Anisembia texana* (Mel.), *Notoligotoma nitens* Davis and *Oligotoma japonica* Okajima, both apterous and alate males occur in the same species.

The genitalia of both sexes are highly specialized. Only in rare cases do the females show very slight evidences of armature of the genital segments. This reduction is probably also due to neoteny. The males have no prominent true phallic structures, secondary developments of the ninth and tenth segments and cerci apparently serving as substitutes. The nature of these terminal developments in the male are of great value to the systematist whereas the females offer characters of but little value. Thus the systematics of the order has been based entirely on the features of the mature male.

BIOLOGY

The biology of the order seems to be remarkably uniform throughout. All species live in silken tunnels spun near or within their food supply. These tunnels may be found under loose bark, among lichens, in matted leaves, about the base of trees, in dry cattle droppings, under stones, in soil cracks, etc. As far as known all species are gregarious and live in what might be regarded as one of the earliest developments of social life among insects. The tunnels unite with one another and each member of the colony may have free access to any part.

The food of the Embioptera is very unspecialized and consists of almost anything of vegetable origin. The preference seems to be for dead plant matter, particularly dried grass and leaves. Unlike many organisms they are perhaps able to seek their optimum environment free from the consideration of food supply as it is almost certain that a potential source is already present wherever they choose to live. This factor has probably been of the greatest importance in the survival of the order into modern times.

Reproduction seems to be largely sexual but parthenogenesis may also occur as explained below. The eggs are very similar in all species, being relatively large, elongate, slightly curved and with a large sloping disc-like operculum. They are laid in clusters attached to the wall of the tunnel in some protected part of the colony. The female remains nearby and apparently attempts to protect the eggs from enemies.

Upon hatching the first instar young are already in an advanced stage of ontogeny and except for small size and certain proportions are almost identical in appearance to the mature female. From the beginning they are able to perform almost all of the activities of the adult although at first they stay close to the protection of the parent female.

The female is without metamorphosis, its development merely consists of increase in size and the attaining of sexual maturity. The male, however, if destined to be winged, produces, in the anti-penultimate instar, small external wing-pads which in the penultimate instar are increased in size and are about twice as long as the thoracic segment. The male terminalia are not differentiated externally until after the last moult although indications of new structures may be seen through the old skin.

Although most observers report but one generation per year, Okajima (1926, *Oligotoma japonica* Okj.) and Friederichs (1934, *Oligotoma nigra* Hagen) record continuous reproduction throughout the year.

In spite of the rather weak appearance of the wings, the males fly readily. Certain species are nocturnal and may be attracted to light while others seem to have a diurnal flight.

Several species have been distributed by commerce throughout the warmer regions of the world and have become well established in new lands.

ANALYSIS OF SYSTEMATIC CHARACTERS

The female: As indicated previously, the females are in a sense but sexually mature larvae and as such do not, and perhaps cannot be expected to, offer significant characters. However, it is naturally desirable that some method be discovered for their determination even if by superficial means. This cannot be done, however, until more females definitely associated with males are available to the student.

Aside from such rather indefinite characters as size, color, chaetotaxy and distribution, the most promising characters of the mature female lie in the nature of the eighth and ninth sternites which seem to offer at least specific differences. In some cases the presence or absence of sole-bladders[5] of the basitarsi (metatarsi) of the hind legs are very useful. Although such bladder characters are of generic value, they are useful only in limited geographic areas as the character appears intermittently, often among unrelated genera, throughout the world.

There does not seem to be much hope of ever finding generic or other higher categoric characters in the female. The use of the width of the first abdominal sternite by some workers for separating families seems to be of little value, varying as it does by degrees.

Only in rare instances, such as the apparent absence of males in a parthenogenetic species, should a new species be described from the female alone.

The male: Unlike the female, the male offers many excellent characters and it is only necessary to use a few of the best for taxonomic

[5]These bladders of the hind tarsi which have been noted and used by a number of workers are of great importance. Usually there are two on the whole tarsus; one being located on the second segment and another terminally on the basitarsus (this may be greatly reduced in some genera). Frequently there is still another located medially on the basitarsus which may not prove to be homologous with others. The presence or absence of this bladder is intra-specifically constant and also seems to be constant in all instars of the species. Davis (1938, p. 271) suggests that these might be used to disengage the ungues from the web.

purposes. Unfortunately, however, great care must be exercised in their use for interpreting the relationship of genera and families since even the characters which are usually most reliable, such as wing-venation and genitalia, may be subject to convergence (sensu Davis, 1938).

The head and eyes offer variations in size and form which seem to be valuable as specific characters but which should be used with caution until their range of variation is known. The basal segmentation of the antennae offers minor specific differences but the number of segments in the antennae as a whole should not be used, except on the basis of a large series, since the terminal segments are very frequently broken or bitten off. The mandibles, in some cases, seem to present generic characters in form and dentation.

The wings, when present, are primarily useful for distinguishing the higher categories but specific differences do exist. They must be used with caution because of the possibility of convergence and of minor variations. In this regard, the number and position of the cross-veins seem to be particularly variable.

The basitarsi of the hind legs are valuable in the male as mentioned above for the female.

Probably the abdominal terminalia provide the most significant characters and the writer recommends that new species should not be proposed on the basis of other characters which are not supported by structural differences in the terminalia. It is further suggested, owing to the complexity of this region of the body, that very careful illustrations of the terminalia, both from the dorsal and ventral aspect from cleared preparations, be made to accompany the description of each species.

The terminalia are almost entirely external and require no dissection for examination. The tenth tergite is often divided submedially by a longitudinal suture (often incomplete basally) forming two unequal hemitergites (10 L and 10 R[6]) each of which may bear processes (10 LP, 10 RP_1, 10 RP_2, etc.) the form of which is very useful. The ninth sternite or hypandrium (H) is generally broad basally and often produced caudad in a process (HP), the nature of which is very significant. The hemisternites of the tenth segment (XL and XR) of the larvae and females are questionably represented in the adults of more specialized genera than *Clothoda* Enderlein, by vestigial sclerites on either side of, or fused to, HP. The cerci, as in the larva and the female, are never more than two-segmented. The left cercus is very often modified; for example, in some genera such as *Anisembia* Krauss and *Metoligotoma* Davis, the terminal segment has become lost in favor of the basal segment. The basal segment may be lobed on its inner side and bear echinulations (minute tooth-like modified hairs) or it may be smooth. The right cercus, although often modified in minor ways, is not important. The left cercus-basipodite (LCB) is often well developed and of great taxonomic value. Ventrally, in some cases, it seems to be a com-

[6]For the sake of uniformity the symbols used for the various parts are those proposed by Davis (1936a et seq.). Contrary to common practice the abdominal tergites are numbered in Arabic numbers, the sternites in Roman numerals.

posite structure partially composed of fused portions of XL. In other instances (i. e., *Oligembia* Davis) it may be fused to the base of the left cercus. The right cercus-basipodite (RCB) is rarely sclerotized and of no importance.

The fact that asymmetry in the terminalia is directed to the left is perhaps explained by, or explains, the mode of copulation (Friederichs, 1934, and writer's observations). The male generally lies on the dorsum of the female and directs its terminalia down the right side of the abdomen thence upward beneath. The left cercus presses against the left side of the female apparently functioning as a clasping organ. The presence of echinulations and lobes, as well as a tendency of the basal segment to become enlarged or elongated in certain genera, seem to add to the efficiency of the cercus in this function. Likewise the processes of the tenth tergite and ninth sternite (which supports the ejaculatory duct) may form a sclerotic sheath for the penis. These processes are often provided with spines, hooks or echinulations which perhaps also aid in insuring successful copulation.

In addition to the above features of the male, such characters as size, color, integumental luster and body proportions are often useful for separating species.

COLLECTION AND PREPARATION OF MATERIAL

As can be seen from the above remarks, it is very important that the collector obtain males. In some species these may be collected in large numbers at light. The writer has found that lights placed against a white wall are particularly attractive to the insects.

In their normal habitats Embioptera are most frequently encountered during and following the rainy season while the soil near the surface is still damp at which time the all-important males often have not yet matured. In this event the collector should obtain immature individuals and rear the two sexes to maturity. Closed jars one-fourth filled with dried grass and leaves kept moderately moist will be found satisfactory for such rearing.

The insects are best preserved in vials of 70% alcohol and should not be mounted dry (dried specimens can, however, be very well recovered by the process of clearing in KOH). For careful study it is often desirable to clear[7] specimens. These may then be mounted on slides in balsam or run back into alcohol.

GENERAL SYSTEMATICS

Owing perhaps to the well defined characters of the group, insects of other orders have seldom been confused with the Embioptera. The only case known to the writer is the suggestion by Edwards (Nat. Hist. Mag., 1: 115) that the Gryllotalpoid genus *Cylindracheta* might belong to the order. Navás (1918) goes further and actually establishes

[7](1) KOH (10%)—five to twelve hours (cold)—slowly tease and press out *all* body contents with a bent, flattened needle.
(2) Glacial Acetic Acid—30 minutes.
(3) Oil of Cloves—until clear (15–30 minutes).
(4) Mount in Canada Balsam—support coverslip with bits of broken glass just large enough to prevent crushing.

a new suborder Oryttica to contain the South American *Cylindracheta spegazzinii* Giglio-Tos! The absolute fallacy of this grouping has been pointed out by Crampton (1928).

The first monograph of the order from the world standpoint was that of Hagen (1885) in which 17 species were recognized. Since then only two others have been written. These appeared almost simultaneously, the first by Krauss (1911) including about fifty species, the second by Enderlein (1912) covering sixty species. However, at the time of this writing a series of papers by Consett Davis treating the Embioptera of the world is beginning to appear. (Proceedings of the Linnean Society of New South Wales, Vol. 64, et seq.). The number of species considered by him will be about 140.

Major groupings in most of the older classifications are based primarily on wing venation. Enderlein (1912), for example, defines two families; Embiidae and Oligotomidae, the former with R_{4+5} forked, the latter with R_{4+5} simple. Recent studies by Davis and the writer indicate that simplification of R_{4+5} is apt to be convergent and that such genera, for example, as *Oligotoma* Westwood, indigenous to the old world (Davis, 1939a, p. 188) and *Anisembia* Krauss of North America both of which have R_{4+5} simple, seem to have achieved this condition independently. It is desirable, therefore, that a new family classification be devised based on a new combination of characters. (This, will be undertaken by Davis in the following paper.) A few new groupings will, however, be used in the present revision.

THE EMBIOPTERA OF NORTH AMERICA

The literature concerning the North American Embioptera is very scanty and it is surprising to note that some of the most common species occurring in the region have never been recorded. This lack of attention is also reflected in the very small and incomplete collections of the order (if indeed any) possessed by the major entomological institutions of this country. Perhaps all of this is due to the fact that the order rarely ranges into the areas most frequently visited by entomologists and to general neglect. It is hoped that this paper may stimulate collectors to secure more material in the order particularly from Mexico and the West Indies.

KEY TO THE FAMILIES OF NORTH AMERICAN EMBIOPTERA[8]

1. Males, females and young with but one (or no) hind basitarsal sole-bladder (fig. 3) 2
   Females and young (males apparently absent) with two hind basitarsal sole-bladders (fig. 4) ..... Genus **Gynembia**
2. Males with wings with R_{4+5} forked (fig. 1); left cercus-basipodite fused to basal segment of left cercus; left cercus always two-segmented, never echinulate on inner side ..... Genus **Oligembia**
   Males with wings (when present) with R_{4+5} simple (fig. 2) when wings are absent the left cercus is one-segmented; left cercus-basipodite not fused to basal segment of left cercus; left cercus either one or two-segmented, echinulate or non-echinulate on inner side of basal segment 3

[8] I have included two genera in this key. The first cannot be satisfactorily referred to any existing family; the second belongs to a new family which will be named in the following paper.

3. Left cercus of male generally bearing echinulations on inner side of basal segment (when not echinulate, tenth tergite completely cleft), often one-segmented; mandibles without apical dentations (condition in *Saussurembia* not known)..... **Anisemdiibae** (4)
   Basal segment of left cercus of male always smooth on inner side, cercus always two-segmented; tenth tergite not cleft to base; mandibles with distinct apical dentations..... **Oligotomidae**
4. Left cercus of male two-segmented..... **Mesembiinae**
   Left cercus of male one-segmented..... **Anisembiinae**

The following genus belongs to a new family to be named and defined by Consett Davis in the next paper in this journal.

Genus **Oligembia** Davis

Oligotoma Hagen, 1885, Can. Ent., 17: 142.
Rhagadochir Enderlein, 1912, Coll. Zool. Selys Longch., 3: 61.
Embia Navás, 1918, Broteria (ser. Zool.), 16: 101.
Oligembia Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 217.

Males: Winged; small sized. Color pale yellowish-brown. *Head* with eyes moderate to large sized, facets large; mandibles small, slender, minutely dentate apically. *Wings* slender, pale; veins not prominent, R_1, R_{2+3} and Cu_{1b} of both wings alone represented by pigmented lines, the others by but rows of macrotrichiae and the usual bordering pigment bands; R_{4+5} forked; M and Cu_{1a} simple, macrotrichiae sparse. *Hind basitarsi* without bladders; ventral setae sparse, rather long. *Terminalia* with tenth tergite produced well forward beneath ninth tergite; dividing suture obsolete basally; left process (10 LP) broad, truncate, often complex apically; right process (10 RP_1) elongate, acute (resembling that of *Oligotoma*); process of ninth sternite (H) not prominent; left cercus two-segmented, basal segment not echinulate; left cercus-basipodite (LCB) large, generally (if not always) fused to LC_1 and produced on inner side.

Female: No mature examples available for study.

Genotype: Oligotoma hubbardi Hagen.

Distribution: Florida, Mexico, West Indies, Central and South America.

This recently proposed genus consists of a relatively large number of species which appear to be limited to the more tropical regions of America. It can be separated from all other genera occurring within the geographic limits of this paper by the forked R_{4+5} of both wings and the peculiar nature of the left cercus-basipodite.

In addition to the three species considered at this time, four others are known: *O. rossi* Davis from Panama, Canal Zone, *O. banksi* Davis from Paraguay, *O. oligotomoides* (Enderlein) of South America and an undescribed species from Guatemala. The description of the last mentioned and a

key to all the species of the genus is in preparation by the author. Two broken undescribable male specimens of this genus from Brownsville, Texas, indicate the presence of still other species of *Oligembia* within the borders of the United States.

KEY TO THE NORTH AMERICAN SPECIES OF OLIGEMBIA
(MALES)

1. Left cercus-basipodite with but a single inner projection.....2
   Left cercus-basipodite with an additional inner lobe distad to usual inner projection. Tres Marias Is.....**pacifica**
2. Left process of tenth tergite large, extending over inner projection of left cercus-basipodite which is bifurcate distally. Florida.....**hubbardi**
   Left process small, terminating at basal margin of left cercus-basipodite; inner projection of left cercus-basipodite not furcate distally. Virgin Is..**brevicauda**

Oligembia hubbardi (Hagen)

(Figs. 5–7)

Oligotoma hubbardi Hagen, 1885, Can. Ent., 17: 142; Schwarz, 1888, Proc. Ent. Soc. Wash., 1: 94 (Biol.); Krauss, 1911, Zoologica von Chun, 23: 44; Enderlein, 1912, Coll. Zool. Selys Longch., 3: 91.
Embia (*Oligotoma*) *hubbardi* Melander, 1902, Biol. Bull., 3: 21.
Oligembia hubbardi Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 218, figs.

Male (on slide): *Color* very pale yellowish-brown throughout, head and terminalia darker, wings lighter. *Dimensions*—length 4 mm.; fore-wing, length 3.7 mm., breadth 1.0 mm. (dimensions of holotype, after Davis).

Head (fig. 5) elongate; sides behind eyes nearly straight subparallel, evenly rounded behind; eyes dark, rather large, inflated facets large; mandibles elongate, apices curved ventrad and minutely dentate.

Wings pale, slender; Sc short, basal; R_1 narrow, parallel with costa throughout, curved before apex and joining R_{2+3} subapically; R_{2+3} only vein traceable by a pigmented line, other veins only represented by rows of sparse macrotrichiae and the usual bordering pigment bands; R_{4+5} forked near its base; hyaline stripes broad, not sharply defined.

Terminalia (figs. 6 and 7) with tenth tergite broadly, asymetrically produced well forward beneath ninth tergite, not divided into hemitergites by a suture; produced caudad submedially in a process (10 LP) which is broad throughout, truncate and complex at apex; right process (10 RP_1) not directly jointed to tergite but attached by a membrane, long, sharply acuminate, curved to right at apex, not bearing dorsal claw-like structures subapically, overlying on inner side at base a narrow flap-like process. Ninth sternite (H) broad, produced caudad as a submedial, small, weakly sclerotized process (HP). Left cercus-basipodite (LCB) large, fused to basal segment of left cercus, produced mesad beneath tip of 10 LP, this projection terminating in a small bifurcate tip curved dorsad and thence towards left cercus. Left cercus with basal segment (LC_1) constricted basally but swollen on inner side near apex.

Female: No mature examples available for study.

Holotype, male (Mus. Comp. Zool.) from Enterprise, FLORIDA, May 24, collected by H. G. Hubbard.

Plesiotype, (designated by Davis, l. c., p. 219), male on slide (Mus. Comp. Zool.) from Royal Palm Park, Florida, March, collected by W. S. Blatchley.

Plesiotype, (by present designation), male on slide (U. S. N. M.), from St. Petersburg, Florida, in "drift debris on shore of Tampa Bay." Above description and figures are based on this specimen (stained with acid-fuchsin).

Additional records: One male, Biscayne Bay, Florida, May 17, (H. G. Hubbard), (U. S. N. M.); two males and two immature females in alcohol with same data as Davis' plesiotype (M. C. Z.).

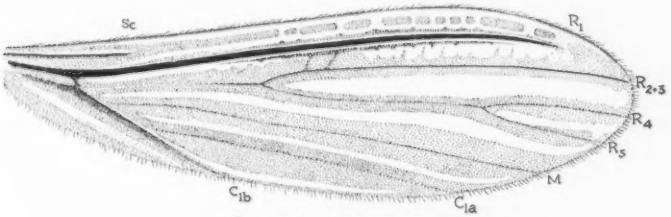
According to Davis (l. c., p. 219) who studied Hagen's type of this species, the specimen is in very poor condition but sufficient structures are preserved to identify it as an *Oligembia* and to associate with it a series of three males from Royal Palm Park, Florida. One of these was mounted on a slide, described, illustrated and designated a plesiotype by Davis. Through the kindness of Dr. Banks I have borrowed this slide as well as alcoholic specimens (including but one male, this lacking terminalia) from the Museum of Comparative Zoology.

Owing to the small size of this species and the poor preparation of the terminalia, it is not hard to explain certain discrepancies in Davis' illustrations (l. c., figs. 3 and 5). The "claw-like hooks" of the process of the right hemitergite (10 RP_1) described and figured by him after careful examination seem actually to be bits of foreign matter in the balsam. The statement by him that such structures also occur on 10 RP_1 of Hagen's type is therefore perhaps incorrect. The basal condition of 10 RP and the ventral aspect of the hypandrium and left cercus-basipodite also need clarification.

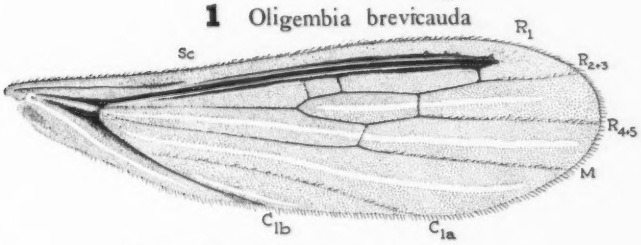
For this reason the present description and illustrations are based on a more perfect specimen from St. Petersburg, Florida, which, although not agreeing closely in the form of the head and the nature of the tip of the process of the left hemitergite, has, after some hesitation, been considered conspecific with the Davis plesiotype.

None of the three male specimens at hand present exactly the same head and terminalia details. Whether this is inter- or intra-specific variation can only be shown, of course, by a larger series.

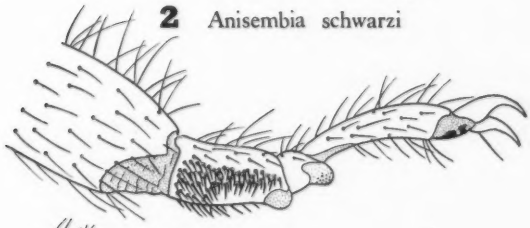
Schwarz (1888) reports this species is not uncommon in Southern Florida occurring singly in the galleries of wood-boring insects. Whether this is actually *hubbardi* and whether this type of occurrence is universal, require verification.



1 Oligembia brevicauda



2 Anisembia schwarzi



3 Oligotoma nigra

4 Gynembia tarsalis

Fig. 1, *Oligembia brevicauda*, fore-wing of holotype male (40 ×); fig. 2, *Anisembia schwarzi*, fore-wing of holotype male (39 ×); fig. 3, *Oligotoma nigra*, left hind tarsus of female (62 ×); fig. 4, *Gynembia tarsalis*, left hind tarsus of female (62 ×).

Oligembia brevicauda Ross, new species

(Figs. 1, 8–10)

Male (In alcohol; terminalia cleared, on slide): Small, winged; very similar in all respects to *hubbardi*. *Color* very pale straw-yellow throughout, with reddish-brown pattern; head dark reddish-brown in clypeal region; terminalia similar in color to rest of abdomen. *Dimensions*—Length 5 mm.; fore-wing, length 4 mm., breadth 1 mm.

Wings (fig. 1) with fork of R_{4+5} located within terminal half of vein in fore-wing, within basal half in hind-wing; hyaline stripes broad and irregular in anterior part of wing, rather narrow and definite in hind portion.

Terminalia (figs. 9 and 10) small. Tenth tergite transverse, short, not extending far forward beneath ninth tergite; left process (10 LP) small, short (terminating at basal margin of left cercus-basipodite), narrow, parallel-sided, apex truncate, simple, heavily sclerotized; right process (10 RP_1) small, thick, short, strongly curved ventrad, apex sharply pointed and slightly curved to the right. Ninth sternite (H) as in *hubbardi*; process (HP) curved dorsad to left of and beneath 10 LP. Left cercus-basipodite (LCB) with a single, slender inner projection, sharply pointed, not furcate at apex. Basal segment of left cercus (LC_1) very short, stout. Basal segment of right cercus very broad basally, short, stout.

Female: Unknown.

Holotype: Winged male (in alcohol, terminalia and fore-wing on slide), (Cat. No. 53980, U. S. N. M.), from St. Croix, VIRGIN ISLANDS, collected June 20, 1939, "under rubbish" by H. A. Beatty (U. S. N. M., Coll.).

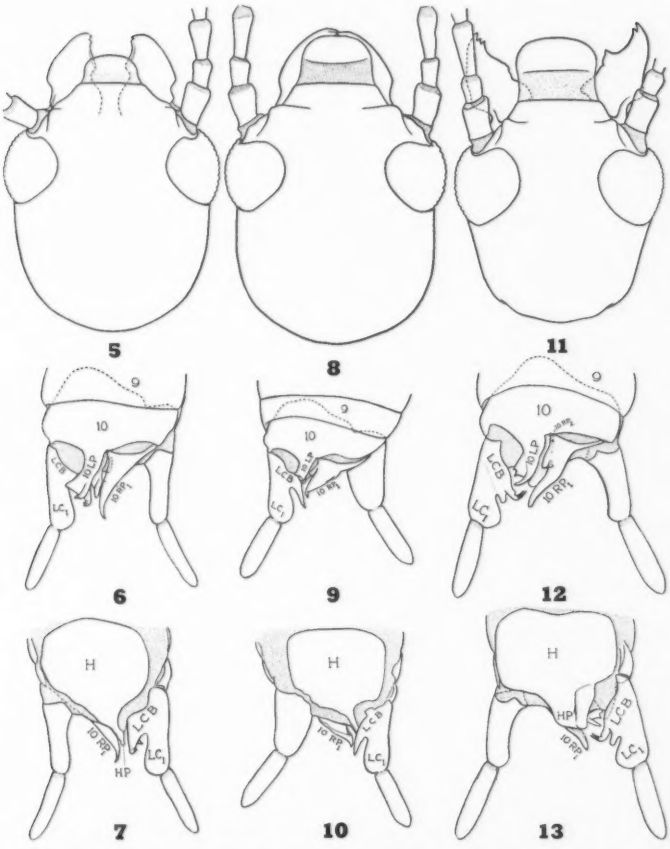
This, the first *Oligembia* known from the West Indies, is very closely related to *hubbardi* of Florida. The very small, short left process of the tenth tergite, the non-furcate inner projection of the left cercus-basipodite, the thicker, shorter, ventrally-curved right process of the tenth tergite, the stout, short cerci and the apical position of the fork of R_{4+5}, are a few points of differentiation.

Oligembia pacifica Ross, new species

(Figs. 11–13)

Male (cleared on slide): *Color* similar to *hubbardi*. *Dimensions*—Length 5.7 mm.; fore-wing, length 3.5 mm., breadth 0.9 mm.

Head (fig. 11) broad, sides behind eyes short, moderately curved and convergent, broadly and evenly rounded behind; eyes large extending mesad two-thirds distance to median line, not strongly inflated, facets large; mandibles quite similar to those of *Oligotoma*, but shorter, apices not curved ventrad, apex of left mandible three-dentate, the right two-dentate; antennae incomplete.



Figs. 5–7, *Oligembia hubbardi*, plesiotype male: fig. 5, head; fig. 6, terminalia (dorsal); fig. 7, terminalia (ventral). Figs. 8–10, *Oligembia brevicauda*, holotype male; fig. 8, head; fig. 9, terminalia (dorsal); fig. 10, terminalia (ventral). Figs. 11–13, *Oligembia pacifica*, holotype male: fig. 11, head; fig. 12, terminalia (dorsal); fig. 13, terminalia (ventral). All figures drawn to scale (37 ×).

General explanation of figures.—The above figures and those following are semi-diagramatic and are based on Camera Lucida outlines. All were drawn by the author except as otherwise indicated. For the sake of clarity all setae and indications of pattern and relative degree of sclerotization have been omitted except in figs. 38–41. Membranous areas are represented by stippling. In the figures of the head the mandibles have often been spread apart to show their structure. The palpi, terminal antennal segments and facets of the eyes have been omitted. *Explanation of symbols:* 9 = ninth abdominal tergite; 10 = tenth abdominal tergite; 10 L = left hemitergite of tenth tergite; 10 R = right hemitergite of tenth tergite; 10 LP = process of 10 L; 10 RP, 10 RP_1, 10 RP_2 = processes of 10 R; H = hypandrium or ninth sternite; HP = process of H; LCB = left cercus-basipodite; LC_1 = basal segment of left cercus.

Wings similar to *hubbardi* but with hyaline stripes still broader and fork of R_{4+5} present midway in length of vein instead of basal.

Terminalia (figs. 12 and 13) similar to *hubbardi*; 10 LP shorter, with a rather long, narrow, curved continuation of inner margin, outer margin straight, terminating in a sharp point, apex with a sharp submedian projection; 10 RP_1 thick, outer margin sinuous, inner margin partially membranous, apex blunt; 10 RP_2 narrow but larger than in *hubbardi*. Ninth sternite (H) broad, quadrate; process (HP) broad, truncate, with a faint submedial longitudinal suture. Left cercus-basipodite (LCB) large fused to basal segment of left cercus; produced inward and upward as a prominent, sclerotic projection, narrowly bifurcate terminally, this is subtended by a blunt, membranous, finger-like lobe. Basal segment of left cercus (LC_1) swollen apically. Basal segment of right cercus strongly sclerotized along inner margin.

Female: Unknown.

Holotype: Male, on slide, (No. 4933, Calif. Acad. Sci., Ent.) collected on Magdalena Island, TRES MARIAS ISLANDS (off west coast of Mexico), May 19, 1925, by Mr. H. H. Keiffer, from the collection of the California Academy of Sciences.

This species is related to the above two as well as to *banksi* Davis of Paraguay. It can be separated from the three by the presence of the second inner projection of the left cercus-basipodite. Further differences between it and the other species in the details of the processes of the terminalia and the head can be seen in the accompanying figures.

FAMILY **ANISEMBIIDAE** (by present designation)

Very small to large North American Embioptera. *Males: Head* very variable in form; eyes small to large sized; mandibles subequal, generally short, arcuate, sharply pointed apically and without inner apical dentations. *Wings* present or absent (both alate and apterous males may occur in the same species); venation "oligotomoid," i. e. R_{2+3} and R_{4+5} simple in both wings. *Basitarsi* of hind legs with but one bladder. *Terminalia* with left cercus one or two-segmented; basal segment often lobed on inner side and bearing echinulations (except in *Saussurembia*).

Females: Basitarsi of hind legs with but one bladder.

Type Genus: Anisembia Krauss.

KEY TO THE GENERA, SUBGENERA AND SPECIES OF THE FAMILY ANISEMBIIDAE (MALES)

1. Left cercus two-segmented (**Mesembiinae**) 2
   Left cercus one-segmented (Genus **Anisembia**) 4
2. Basal segment of left cercus nodulose and echinulate on inner side (Genus **Mesembia**) 3
   Basal segment of left cercus smooth ..... **Saussurembia**

3. Basal segment of left cercus with echinulate nodule located medially, **Mesembia hospes**
   Basal segment with nodule located distally..... **Mesembia haitiana**
4. Submedian suture of tenth tergite incomplete basally; left cercus with a very distinct, subapical inner nodule; basal segment of right cercus cylindrical, basal foramen circular.....5
   Submedian suture of tenth tergite complete to base; left cercus without a distinct, subapical inner nodule; basal segment of right cercus laterally compressed, basal foramen elliptical.....7
5. Inner nodule of left cercus small, very sparsely echinulate; head scarcely larger than terminalia. (**Anisembia** s. str.).....6
   Inner nodule of left cercus large, rounded, very densely echinulate; head distinctly larger than terminalia..... **A. (Bulbocerca) sini**
6. Process of left hemitergite rather short, extending straight back; process of right hemitergite simple; medium sized..... **A. (Anisembia) texana**
   Process of left hemitergite very long, strongly curved to left; process of right hemitergite complex; size small..... **A. (Anisembia) schwarzi**
7. Right hemitergite produced caudad as a distinct process bearing one or two outwardly-curved, claw-like hooks; left cercus not greatly elongated or very strongly inwardly arcuate. (Subgenus **Chelicerca**).....8
   Right hemitergite not produced caudad as a process and not bearing claw-like apical hooks; left cercus greatly elongated; strongly inwardly arcuate. **A. (Dactylocerca) rubra**
8. Process of right hemitergite with but one outwardly-curved, claw-like apical hook.....9
   Process of right hemitergite with two such hooks... **A. (Chelicerca) heymonsi**
9. Apical hook of process of right hemitergite arising on inner side of process and curving across its apex..... **A. (Chelicerca) wheeleri**
   Apical hook arising terminally, not overlapping any tergal structure, **A. (Chelicerca) davisi**

Subfamily **Mesembiinae** (by present designation)

Anisembiidae with left cercus of male two-segmented.

Genus **Mesembia** Ross

Oligotoma Myers, 1928, Bull. Brooklyn Ent. Soc., 23: 89.
Mesembia Ross, 1940, Pan-Pac. Ent., 16: 12.

Males: Winged; medium to large sized. *Head* with eyes large; mandibles small, short, apices acutely pointed, non-dentate. Wings large; pigment bands broad, dark; hyaline stripes narrow, clearly, sharply defined. *Hind basitarsi* with but one bladder. *Terminalia* with tenth tergite divided submedially, each of the thus-formed hemitergites bearing distinct caudal processes; process of hypandrium not prominent; left cercus two-segmented, the basal segment with an echinulate nodule on inner side; left cercus-basipodite not prominent, ventral.

Female: No mature examples available.

Genotype: Oligotoma hospes Myers.

Distribution: West Indies.

The two-segmented, echinulate left cercus in combination with the oligotomoid venation will distinguish *Mesembia* from all other known genera.

The characters seem to be much like those that might be expected in the hypothetical ancestor of the genus *Anisembia*.

Indeed the only modification necessary to produce the characters of an *Anisembia* would be the loss, by reduction, of the terminal segment of the left cercus. The other structures of the terminalia can be closely compared between the two genera.

The genus consists of the following two rather distantly related antillean species.

Mesembia hospes (Myers)

(Figs. 14–16)

Oligotoma hospes Myers, 1928, Bull. Brooklyn Ent. Soc., 23: 89, fig. 1.
Mesembia hospes Ross, 1940, Pan-Pac. Ent., 16: 12.

Male (Paratype in alcohol): *Color* uniform brown throughout, head somewhat darker. *Dimensions*—Length 8.5 mm.; fore-wing, length 8 mm., breadth 2 mm.

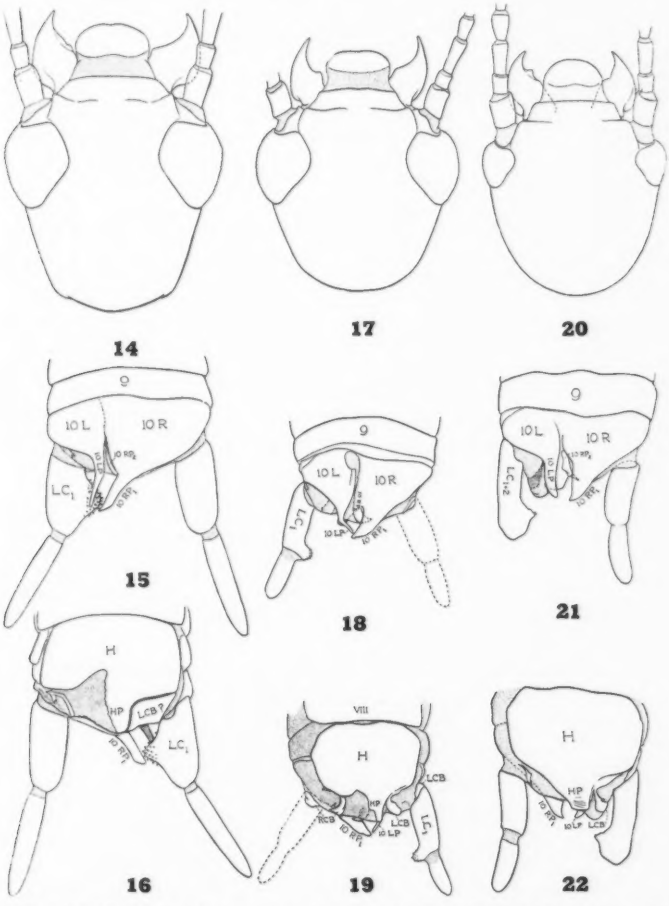
Head (fig. 14) larger than terminalia, clothed with rather long hairs, basal pattern present; sides behind eyes nearly straight, gradually convergent, base abruptly transverse, and somewhat obtusely angulate medially; eyes black, large, inflated, extending well mesad, facets moderate sized; left mandible with inner surface smooth, not evenly emarginate, possessing a small basal notch; right mandible with inner surface smooth, evenly emarginate, not notched; antennae with first and second segments dark brown, the remainder tan, segments rather long, slender, at least 19 segments present (incomplete).

Wings: Tan, fore-wing with Sc not quite half wing-length, R_1 strong, abruptly terminating apically before attaining margin; R_{2+3} entire, simple, faintly pigmented; R_{4+5} pigmented only in basal fourth, continued to margin by row of close-set macrotrichiae; M and Cu_{1a} unpigmented, represented by rows of close-set macrotrichiae to margin; cross-veins faint, three present apically between R_1 and costal margin, three present between R_1 and R_{2+3}, two of these near tip of R_1, the other near fork of Rs, one between R_{2+3} and R_{4+5} and also R_{4+5} and M. Hind wings similar to fore-wings but differing in that the cross-veins between R_1 and R_{2+3} are evenly spaced and that the macrotrichiae of Cu_{1a} are almost obsolete.

Terminalia (figs. 15 and 16): Color rather even brown; cerci large, clothed with long setae. Tenth tergite with submedian suture not appearing (in alcohol) to attain base; left hemitergite (10 L) small, bearing a very slender, slightly sinous process (10 LP) which gently curves to the left; right hemitergite (10 R) broad, bearing a flattened, parallel-sided, truncate process (10 RP_1) directed to the left, its apex converging close to the tip of 10 LP and curving ventrad; a narrow, inconspicuous sclerite lying close to sutural margin of 10 R probably represents 10 RP_2. Ninth sternite (H) broad, deeply, acutely emarginated in left apical angle; broadly, obtusely emarginate in right angle to accommodate the left cercus-basipodite (LCB?); scarcely produced medially as a short, rounded process (HP). Left cercus-basipodite not apparent dorsally, but perhaps represented as the broad, ventral rec-

tangular sclerite in the right emargination of H. Left cercus two segmented, the basal segment (LC_1) large, globose; inner side produced medially as a large conical nodule bearing numerous conspicuous echinulations; the terminal segment longer than LC_1, slender. Right cercus with basal segment large, cylindrical, simple.

Female: No mature examples available.



Figs. 14–16, *Mesembia hospes*, paratype male: fig. 14, head; fig. 15, terminalia (dorsal); fig. 16, terminalia (ventral). Figs. 17–19, *Mesembia haitiana*, holotype male: fig. 17, head; fig. 18, terminalia (dorsal); fig. 19, terminalia (ventral). Figs. 20–22, *Anisembia* (*A*) *texana*, plesiotype male: fig. 20, head; fig. 21, terminalia (dorsal); fig. 22, terminalia (ventral). All figures drawn to scale (22 ×). (Explanation of symbols under figs. 5–13, p. 641.)

Holotype: (Terminalia on slide, rest of body in alcohol), (No. 523, M. C. Z.) and numerous paratypes from Soledad, Santa Clara, CUBA, February 10, 1925, (J. G. Myers). The paratypes are deposited in the Museum of Comparative Zoology, the British Museum and the Myers collection.

Distribution: Known only from the type citation.

Dr. Banks very kindly loaned me two males and two female (immature) paratypes of this species from the Museum of Comparative Zoology Collection. The above description and the accompanying figures are based on this material. The writer is also grateful to Mr. Consett Davis for his notes and illustrations relating to this species made at the Museum of Comparative Zoology during his visit there.

Myers' figure of the terminalia indicates that it was made from a distorted specimen. Davis, upon examining this specimen, the holotype, found it to be badly crushed by the coverslip.

The series of specimens deposited in the Museum of Comparative Zoology by Myers consists largely of immature forms, a few adult females and two males besides the holotype. According to Davis (in litt.) "no female approached 25 mm. in length, as claimed by Myers; the greatest length was 12 mm.; 25 mm. must be a *lapsus calami* for 12.5 mm."

Myers reports that he found the species in a huge colony, a continuous nest covering the trunk and larger branches of a large Physic bean tree (*Cassia fistula*). In this colony he also found specimens of the Monommid beetle *Hyporrhagus marginatus* (Fabr.) which he claims lives with the Embiopterons as a facultative embiophile.

As can be seen by comparing the figures of the terminalia, this species is very distinct from the following.

Mesembia haitiana Ross, new species

(Figs. 17–19)

Male (on slide): *Color* uniform light chocolate-brown throughout. *Dimensions*—Length 8.5 mm.; fore-wing, length 5.5 mm., breadth 1.5 mm.

Head (fig. 17) small in relation to other body proportions, clothed with sparse long hairs, basal pattern absent; sides behind eyes short, strongly convergent, base evenly rounded; eyes light, large, inflated, facets small; mandibles small, subequal, inner emarginations of both smooth, similar; antennae with basal segment large, brown; other segments slender, straw-yellow; terminal segments lost.

Wings large, brown; fore-wing with Sc one-third wing-length; R_1 strong, nearly attaining costal margin apically; R_{2+3} and R_{4+5} simple, both pigmented to margin; M and Cu_{1a} represented only by rows of macrotrichiae, these are obsolete in hind-wing; three cross-veins present between R_1 and R_{2+3}, one apical and two close together near latter's base, one also present between R_{2+3} and R_{4+5} midway in length, in hind wing these are fainter and fewer in number.

Terminalia (figs. 18 and 19): Very small, brown. Tenth tergite with submedian suture entire to base, with a small, oval, unpigmented spot at its base extending into area of left hemitergite (10 L); 10 L one-third size of right hemitergite (10 R), triangular, produced caudally in a very slender, acuminate process (10 LP) which abruptly turns inward and upward at apex; 10 R produced as a broad, blunt process (10 RP_1) curving ventrad and also as a smaller process (10 RP_2) lying along sutural margin, curving ventrad and to the right partially beneath 10 RP_1. Ninth sternite (H) broad, suboctagonal; process (HP) short, narrow, truncate at apex. Left cercus-basipodite (LCB) present as a small half-ring on outer basal margin of the basal segment of left cercus (LC_1) and possibly also as the small, elongate ventral sclerite (LCB) fused basally with hypandrium. Left cercus two-segmented, the basal segment (LC_1) tubular, sides subparallel except for a prominent, distinctly-echinulate nodule present on inner side at apex. Right cercus broken off. Small fragmentary sclerites located dorsally and ventrally at usual point of attachment of right cercus probably represent the right cercus-basipodite (RCB).

Female: Unknown.

Holotype, winged male on slide, (U. S. N. M. Cat. No. 53132), collected at Grosmorre, HAITI, February 17, 1926, by C. H. Leonard.

This species is of special interest for, as can be seen by comparing the figures of its terminalia with those of certain species of *Anisembia* such as *texana* (Melander), there is a close similarity of structures. This together with the indication that the terminal segment of the left cercus of *haitiana* is becoming reduced in favor of the basal segment seems to strongly indicate an ancestral relationship with *Anisembia*.

Genus **Saussurembia** Davis

Embia de Saussure, 1896, Mitt. Schweiz. Ent. Ges., 9: 353.
Oligotoma Krauss, 1911, Zoologica, 23: 42; Enderlein, 1912, Coll. Zool. Selys Longch., 3: 91; Navás, 1924, Broteria, Serie Zoologica, 21: 62; Banks, 1924, Bull. Mus. Comp. Zool., 65: 421; Friederichs, 1934, Arch. Naturg., 3: 417.
Saussurella Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 573.
Saussurembia Davis, 1940, l. c., 65:—.

Davis' generic diagnosis is quoted as follows:

"Small Neotropical Embioptera, the males with the following characters: Winged, R_{4+5} simple, terminally subobsolescent; M and Cu_{1a} simple, subobsolescent. Hind tarsi with only one metatarsal bladder.

Tenth abdominal tergite completely cleft, right hemitergite with an elongate posterior process, but without any process on the inner margin. Process of left hemitergite simple. Left cercus composed of two subcylindrical segments of equal length, the first slightly thickened distally, but without nodules."

Genotype: Embia ruficollis de Saussure.

Distribution: Central America and West Indies.

I am tentatively placing this genus in the Mesembiinae on the basis of the two-segmented left cercus. It differs from all other genera of the Anisembiidae in that the basal segment of the left cercus is not echinulate or nodulose on the inner side. It may be separated from *Oligotoma* (at least the species present in America), with which certain of its characters are convergent, by the completely cleft tenth tergite, the absence of a flap-like process, (10 RP_2, of *Oligotoma*) lying partially beneath the inner margin of the process of the right hemitergite and the much smaller size of its species.

Two species have been referred to the genus: *Embia ruficollis* de Saussure of Central America (Davis' interpretation is not based on de Saussure's type but is probably correct) and *Oligotoma venosa* Banks of Cuba.

Saussurembia (?) venosa (Banks)

Oligotoma venosa Banks, 1924, Bull. Mus. Comp. Zool., 65: 421, Pl. I, figs. 10 and 13.
Saussurella venosa Davis, 1939c, Proc. Linn. Soc. N. S. W., 64: 574. figs. 5–7.

Holotype: Winged male, on slide, from Santa Clara, CUBA (Baker). Type number 14879, Museum of Comparative Zoology.

According to Davis (in litt.) this is probably a distinct species and apparently not the same as my *Anisembia schwarzi* or Myer's *Mesembia hospes*, both also occurring in Cuba.

The camera lucida figures of the type furnished me by Davis together with his comments indicate that the terminalia of the type are in very poor condition. The generic position of the species is problematical (it is certainly not an *Oligotoma*) owing to the disarrangement of the left cercus. Davis only provisionally places it in *Saussurembia* and suggests that it might later prove to actually be a *Mesembia* or an *Anisembia*. As soon as possible the species should be redescribed from topotypical material very carefully compared with the type.

SUBFAMILY **ANISEMBIINAE** (by present designation)

Medium to very small sized Anisembiidae with left cercus of male always one-segmented.

Genus **Anisembia** Krauss

Olyntha Melander, 1902, Biol. Bull., 3: 17.
Embia Melander, l. c., p. 19; Melander, 1903, l. c., 4: 99.
Anisembia Krauss, 1911, Zoologica von Chun, 23: 74; Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 345.
Haploembia Enderlein, 1912, Coll. Zool. Selys Longch., 3: 70, 109.
Oligotoma Enderlein, l. c., p. 109, 114; Mills, 1932, Ann. Ent. Soc. Amer., 25: 648.

Males: Apterous or alate, size generally small. *Head* with eyes usually small; mandibles short, arcuate, apices acutely pointed, nondentate. *Wings* (when present) generally small, narrow; venation oligotomoid; pigment bands often broad; hyaline stripes narrow. *Hind basitarsi* with but one bladder. Terminalia with tenth tergite divided into hemitergites by a suture complete or incomplete to base. Left cercus one-segmented, often nodulose and always echinulate on inner side near apex.

Females: *Hind basitarsi* with but one bladder.

Genotype: Embia texana Melander.

Distribution: Cuba, Mexico, Texas, Mississippi, Arizona, Southern California.

The confused systematic history of this genus has been well discussed by J. C. Chamberlin (l. c., pp. 342–344). It was shown that Enderlein (l. c., p. 109), who placed Krauss' genus *Anisembia* in synonomy with *Haploembia* Verhoeff and *Oligotoma* Westwood, upon his disbelief that the left cercus of the male could actually be one-segmented, was entirely in error.

The genus *Anisembia* is apparently a very natural one, but its species are often so distinct from one another that the writer feels compelled to subdivide it into a number of subgenera. The genus will be further discussed following the consideration of its component species.

Subgenus **Anisembia** s. str.

Males: *Head* scarcely larger than terminalia, rather short; eyes moderately large; mandibles short, small, arcuate. *Wings* (when present) rather broad, light in color; hyaline stripes ragged; R_1 subparallel with costa and rather distant from it throughout its length; crossveins relatively numerous in both wings. *Terminalia* with submedian suture of tenth tergite incomplete basally; process of left hemitergite (10 LP) simple, slender, thin; right hemitergite not incised along sutural margin by membranous emarginations, process (10 RP_1) rather prominent, not bearing apical claw-like hooks. Process of hypandrium (HP)

short, truncate, simple, not echinulate. Ventral portion of left cercus-basipodite (LCB) large, fused basally with side of HP. Left cercus straight, cylindrical, short, stout; swollen and rounded apically (this area is less sclerotized and more densely setose than rest of cercus; it is probably the last vestige of the terminal segment); nodulose on inner side just before apex, this with very few echinulations. Basal segment of right cercus (RC_1) short, cylindrical; basal foramen circular.

Type: Embia texana Melander.
Distribution: Cuba, Texas and Mississippi.

Anisembia (Anisembia) texana (Melander)

(Figs. 20–22, 38)

Embia texana Melander, 1902, Biol. Bull., 3: 19, figs. 2, 3[1]; Melander, 1903, ibid., 4: 99 et seq., figs. 1, 2[2]; Friederichs, 1906, Mitt. Zool. Mus., Berlin, 3: 238.
Anisembia texana Krauss, 1911, Zoologica, 23: 74, fig., F.; Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 345.
Oligotoma texana Enderlein, 1912, Coll. Zool. Selys Longch., 3: 92, 109, fig., 62; Mills, 1932, Ann. Ent. Soc. Am., 25: 648[3].

Alate male (on slide): *Color*—Head pale yellow, antennae and palpi brown; prothorax and forelegs tan; pterothorax and abdomen light chocolate brown, terminalia darker.[9] *Dimensions*—Length 7.5 mm.; fore-wing length 4.52 mm.; breadth 1.25 mm.

Head (fig. 20) larger than terminalia; sides behind eyes very broadly rounded and rather strongly convergent, evenly rounded behind. Eyes prominent but rather small, facets small. Mandibles very sharply pointed and strongly incurved distally, not dentate; left mandible strongly bi-emarginate on inner side, right mandible smooth. Antennae incomplete.

Wings tan; hyaline stripes rather broad, margins ragged. Fore-wing with Sc one-third wing-length; R_1 strong, separate apically, terminating before margin; R_{2+3} and R_{4+5} pigmented to margin, unbranched; two cross-veins between R_1 and R_{2+3} and very faint, incomplete vein between R_{2+3} and R_{4+5}; M not pigmented in apical third, continued to margin by row of macrotrichiae, a single, faint cross-vein between it and R_{4+5}. Cu_{1a} represented only by a row of macrotrichiae and the usual pigment band. Hind wing broader and shorter; two cross-veins present between R_1 and R_{2+3} as well as two between R_{2+3} and R_{4+5} these are very faint; the above longitudinal veins are pigmented, the remainder, M and Cu_{1a} (excluding Cu_{1b}) represented by only the usual pigment bands and rows of very sparse macrotrichiae.

Terminalia (figs. 21 and 22) with submedian suture of tenth tergite incomplete basally; left hemitergite (10 L) small, bearing a gradually tapering process (10 LP) directed straight back but slightly curved to the right apically; right hemitergite (10 R) subtriangular, bearing a broad process (10 RP_1) curved along outer margin but nearly straight along inner side, extreme apex hooked inward; another process (10 RP_2) located within suture is elongate, irregularly shaped, curved slightly

[9]Uncleared fully hardened examples may have the body almost black with a slight bluish metallic luster.

beneath base of 10 RP_1, and is strongly pigmented. Ninth sternite (H) large, subquadrate, produced caudad, forming a broad, truncate, transversely striate process (HP). Left cercus-basipodite (LCB) ventrally narrow, irregular, fused along much of basal margin with H; perhaps also represented dorsally by an outer, half-ring sclerite fused to base of left cercus. Left cercus straight, cylindrical, swollen and rounded distally; bearing a small, sparsely echinulate nodule subapically on inner side. Right cercus with segments short, cylindrical.

Apterous male similar in all respects to the alate male except for the larva-like sclerotization of the meso and metathorax due to the absence of wings.

Female (on slide): Length 10.5 mm. *Head* yellowish-brown; thorax and legs tan; abdomen and cerci light chocolate-brown. *Head* uniform in color, without trace of pattern. *Eighth sternite* (fig. 38) sclerotic at sides only, membranous medially, lateral sclerotic areas very dark brown, subtriangular. *Ninth sternite* (fig. 38) entire across apex but broadly, deeply, obtusely emarginate basally.

Holotype: "immature male" (or female ?) from Austin, Texas (A. L. Melander), deposited in the Museum of Comparative Zoology.

Since it is often difficult (if at all possible) to determine the sex of immature Embioptera (except those bearing wing-pads), the actual sex of the holotype may not be determinable.[10] In this event the mature male described later (1903) by Melander (if preserved) may or may not have the status of an allotype.

Therefore the writer is designating the alate male and the female described and illustrated in this paper plesiotypes as follows:

Plesiotype, winged male, on slide, from Victoria, Texas, April 19th (J. D. Mitchell), (U. S. N. M., Coll.), deposited in the U. S. National Museum.

Plesiotype, female, on slide from Arroyo Salado, Starr Co., Texas, July 5, 1938 (R. H. Beamer), deposited in the Museum of the California Academy of Sciences.

Distribution: Texas and Mississippi.

Records: TEXAS, Pease Park, Austin (A. L. Melander)[1,2]; College Station, March 20, 1931, "in Spanish moss" (C. S. Siddal)[3]; Milano, April 16, 1931 (V. A. Little)[3]; Easterly, May 16, 1931, "in bark of stumps"[3]; Millican, July 19, 1931 (H. J. Reinhard)[3]; Bryan, July 26, 1931[3]; Columbus, August 14, 1894, one male "flying in cotton field" (U. S. N. M.); Victoria,

[10]Chamberlin (l. c., p. 345) states without giving his evidence that the holotype is a female.

July 1, 1913, "collected on cotton" (B. R. Coad), (U. S. N. M.); Arroyo Salado, Starr Co., July 5, 1938, "under bark of Mesquite" (R. H. Beamer), (Snow Collection); MISSISSIPPI, Vicksburg, June 15, 1920 (W. B. Laminick), (U. S. N. M.).

Anisembia (Anisembia) schwarzi Ross, new species

(Figs. 2, 23–25)

Male (on slide): Winged. *Color* light tan throughout, terminalia darker; head straw-yellow. *Dimensions*—Length 6 mm.; fore-wing, length 3.5 mm., breadth 0.9 mm.

Head (fig. 23) larger than terminalia; sides behind eyes almost straight, gradually converging; abruptly, broadly rounded basally. Eyes rather large, facets small. Mandibles very acute terminally, not dentate; inner margin of left mandible broadly bi-emarginate, left mandible evenly emarginate. Antennae with at least 15 segments present (incomplete).

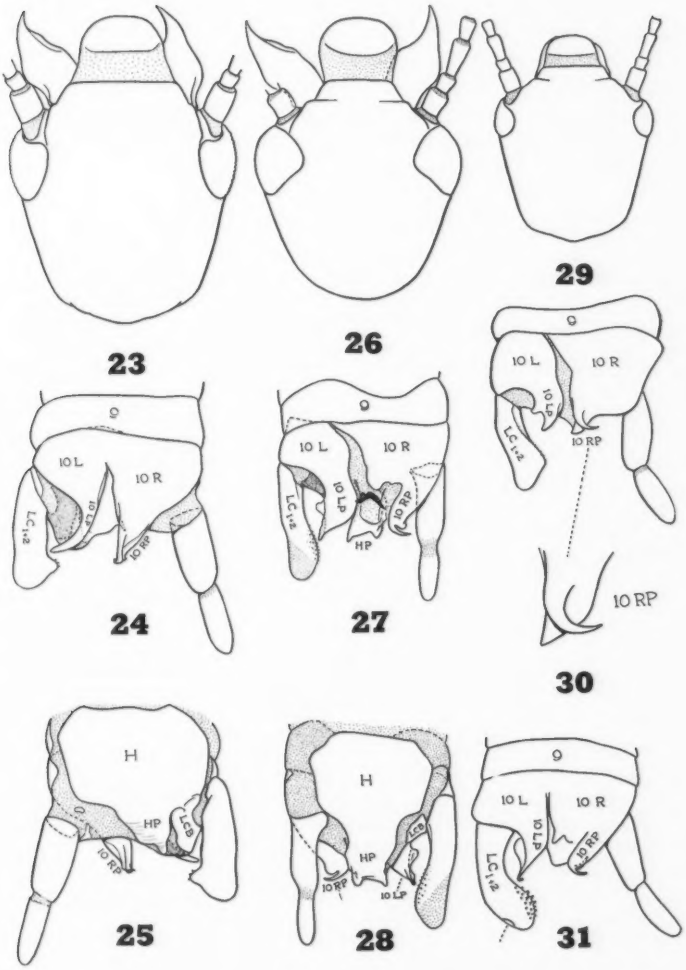
Wings: Color tan, hyaline bands narrow; fore-wing (fig. 2) with Sc nearly one-third wing-length; R_1 broad, terminating before attaining margin; R_{2+3} and R_{4+5} simple, represented by strong pigment lines almost to margin, three cross-veins present between R_1 and R_{2+3} one between R_{2+3} and R_{4+5}; M simple, not pigmented in apical third, one cross-vein present between it and R_{4+5}; Cu_{1a} represented only by row of fine macrotrichiae and the usual pigment band. Hind-wing shorter and broader; venation similar but less strongly represented and with fewer cross-veins; M and Cu_{1a} represented only by their pigment bands and very sparse macrotrichiae.

Terminalia (figs. 24 and 25): Tenth tergite with submedian suture not attaining base; left hemitergite (10 L) small, gradually narrowed and produced caudad to form a long slender process (10 LP) which curves to the left; right hemitergite (10 R) forming a complex angular process (10 RP) abruptly turned downward and truncate distally. Ninth sternite (H) broad quadrate; process (HP) broad with a small finger-like extension. Ventral portion of left cercus-basipodite (LCB) large, fused basally with H; LCB obsolete dorsally except for the small half-ring, sclerite fused to base of left cercus. Left cercus short, stout; broadly rounded at apex with a small inner nodule bearing three small, but distinct, echinulations. Right cercus normal, segments cylindrical, short.

Female: Unknown.

Holotype: (Cat. No. 53978, U. S. N. M.) winged male on slide from Cayamas, Santa Clara, CUBA, "5.6," collected by E. A. Schwarz for whom the species is named.

In addition to the above, five other specimens which are immature (one a penultimate male) and which bear the same data as the holotype probably represent this species. These and the holotype are from the United States National Museum Collection.



Figs. 23–25, *Anisembia* (*A*) *schwarzi*, holotype male: fig. 23, head; fig. 24, terminalia (dorsal); fig. 25, terminalia (ventral). Figs. 26–28, *Anisembia* (*Chelicerca*) *davisi*, holotype male: fig. 26, head; fig. 27, terminalia (dorsal); fig. 28, terminalia (ventral). Figs. 29 and 30, *Anisembia* (*Chelicerca*) *wheeleri*, holotype male (drawings furnished by Davis); fig. 29, head; fig. 30, terminalia (dorsal). Fig. 31, *Anisembia* (*Chelicerca*) *heymonsi*, terminalia (dorsal) of holotype male adapted from Enderlein (1912). All figures drawn to scale (33 ×). (Explanation of symbols under figs. 5–13, p. 641.)

This species is of particular interest as it is the first *Anisembia* known from the West Indies. The wing venation is stronger and more complete than any other known species of the genus. This feature, as well as the structure of the terminalia, seems to relate it to *texana*. The very long, slender, curved process of the left hemitergite will immediately distinguish it from all other species of the genus.

Subgenus **Bulbocerca** Ross, new subgenus

Males strongly neotenic; apterous. *Head* distinctly larger than terminalia, elongate-oval; eyes very small; mandibles large, elongate, not strongly arcuate. *Terminalia* simple, weakly sclerotized. Submedian suture of tenth tergite incomplete basally; process of left hemitergite (10 LP) short, truncate, simple; right hemitergite not incised along sutural margin by membranous emarginations, process (10 RP) narrow, simple. Process of hypandrium (HP) short, broad, weakly sclerotized, not echinulate. Left cercus short; strongly clavate apically, distal lobe densely setose and membranous; subapical inner nodule large, rounded, very densely echinulate. Basal segment of right cercus simple, cylindrical; basal foramen round.

Type: Anisembia sini Chamberlin.
Distribution: Lower California, Mexico.

Anisembia (Bulbocerca) sini Chamberlin

(Figs. 32–34)

Anisembia sini J. C. Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 346, figs. a-b.

Although Chamberlin's description is very adequate, the following, based on the holotype, is given in the style adopted in this paper. The accompanying figures are, however, made from a specimen compared with the type.

Male (on slide): Apterous. *Color*—Body, legs and terminal segments of antennae very dark chocolate-brown, almost black; head and two basal antennal segments reddish-yellow. Length–9 mm.

Head (fig. 32) very large, sides nearly straight, gradually converging caudad, broadly rounded behind; basal pattern present but faint. Eyes very small, larvaform. Mandibles large, elongate, asymmetrical; apices sharply pointed; inner margin of right mandible not evenly emarginate. Antennal segments relatively small.

Terminalia (figs. 33–34) with submedian suture of tenth tergite not quite entire to base; left hemitergite (10 L) small, process (10 LP) curved towards left cercus, sides subparallel, tip abruptly, squarely truncate; right hemitergite margin of 10 R directed toward nodule of left cercus. Ninth sternite (H) broad, quadrate; process (HP) broad, truncate, apical margin not echinulate. Details of left cercus-basipodite not clear. Left cercus cylindrical basally, strongly clubbed distally; this distal lobe less sclerotized and more densely clothed with long setae

than rest of cercus; a broadly rounded, densely micro-echinulate nodule present on inner side at base of distal lobe; inner margin basad to nodule heavily sclerotized, somewhat flattened. Segments of right cercus short, cylindrical.

Female (homotype): *Color* straw-yellow throughout, tinged with pale reddish-brown. *Length*—12 mm. *Hind basitarsi* densely clothed ventrally with slender setae. *Eighth sternite* pigmented on either side, more strongly so posteriorly; membranous medially. *Ninth sternite* very broad, entire; slightly obtusely emarginate basally.

Holotype: Male on slide (uncleared), (No. 1245, Calif. Acad. Sci., Ent.) and allotype female, on slide, (No. 1246) collected under the same stone at Loreto, LOWER CALIFORNIA, MEXICO, by J. C. Chamberlin.

Distribution: (The records not based on male specimens require verification; some are only based on occurrence of webs; unless otherwise indicated all records are those of J. C. Chamberlin.) GULF OF CALIFORNIA ISLANDS: San Esteban; South Santa Inez; Isla Partida of Espiritu Santo; Indian Village, Tiburon; Pond Island; Coronadoes; Carmen; Monserrate; San Josef. PENINSULA OF LOWER CALIFORNIA: Loreto, May 19, 1921, types; del Cuesta Blanca (7 mi. N. of Loreto), (web); Comondu, July 21, 1938, 2 males, females and young under stone (Ross and Michelbacher); 20 to 40 miles north of Comondu, July 22–23, 1938, numerous young under stones along road (Ross and Michelbacher).

In addition to the above records, webs were observed by the writer under stones on the Vizcaino Desert, 50 miles north of San Ignacio. If these were produced by *sini*, the known range of the species would be extended considerably.

At Comondu, where it had not rained, according to the natives, for five years, no specimens were seen under the stones, when first turned, because of the extreme dryness. By pouring water from a nearby irrigation ditch about the same stones, the writer was able to collect a series of specimens the next morning attracted to the surface by the moisture. North of Comondu, where it had rained two weeks previously, specimens were very abundant at the surface of the ground in their tunnels among mesquite leaves and beneath stones. All specimens seemed to be roughly in the same instar, being about half grown.

The males collected by the writer at Comondu are of the same pale color as described in the female (this may be due to too short an interval following ecdysis) and differ also in minor details of the terminalia from the holotype. A large series of

males from a number of scattered localities may prove the existence of subspecies.

In this species neoteny of the male is well advanced. Not only have the wings been lost but the nature of the head, eyes and legs is unusually similar to the larva and female.

Subgenus **Chelicerca** Ross, new subgenus

Males: Head as large or slightly smaller than terminalia, rather short; eyes and mandibles medium sized[11]. *Wings* (when present) very slender, dark; hyaline stripes narrow, margins even; R_1 close to costa and converging toward it distad; cross-veins obsolete. *Terminalia* with submedian suture of tenth tergite complete to base; process of left hemitergite (10 LP) broad, very complex, folded ventrad apically on outer side[11]; right hemitergite often rather deeply, irregularly incised along sutural margin by membranous emarginations, process (10 RP) complex, bearing one or two outwardly-curved claw-like hooks apically. Process of hypandrium (HP) complex; apex irregular, bearing apical fringe of echinulations (in *wheeleri ?*). Ventral portion of left cercus-basipodite (LCB) broad, not fused basally with HP.[11] Left cercus slightly curved inward, not strongly clavate apically or nodulose subapically on inner side; inner margin in apical third densely echinulate over a wide area. Basal segment of right cercus laterally compressed, elongate; basal foramen narrow, elliptical.[11]

Type: Anisembia (*Chelicerca*) *davisi* new species.
Distribution: Mexico.

Anisembia (**Chelicerca**) **davisi** Ross, new species

(Figs. 26–28)

Male (on slide): Winged. *Color*—Head dark chocolate brown; thorax, legs and wings medium brown; abdomen light tan, terminalia darker. *Dimensions*—Length 5.5 mm.; fore-wing, length 4 mm., breadth 0.97 mm.

Head (fig. 26) with sides strongly converging, nearly straight, evenly rounded behind. Eyes prominent but not inflated, facets small. Mandibles large, very sharply pointed distally, non-dentate; left mandible broadly unevenly bi-emarginate on inner side; right mandible simple, evenly emarginate. Antennae incomplete; almost unpigmented except for basal segment.

Wings very slender, dark; hyaline stripes very narrow, abrupt. Fore-wing with Sc one-third wing-length. R_1 narrow, very closely paralleling costa, almost attaining margin at apex; R_{2+3} faintly pigmented; R_{4+5}, M and Cu_{1a} subobsolete, represented only by their pigment bands and rows of very sparse macrotrichiae. Cross-veins absent. Hind wings similar but broader and with veins even less apparent.

---

[11]Character based on the type of the subgenus and assumed to be similar in the other species.

Terminalia (figs. 27 and 28) with submedian suture of tenth tergite complete to base, broad; left hemitergite (10 L) produced caudad as a large, very broad process (10 LP) abruptly folded ventrad along outer margin, this fold somewhat unevenly concave, truncate. Right hemitergite (10 R) broad, deeply emarginate along suture before apex; bearing a nearly parallel-sided process (10 RP_1) which is bifid at apex, one of these forks being small slender, hook-like and directed to the right, the other small, blunt, subterminal. A small isolated, irregular, transverse, deeply pigmented sclerite is present in membrane of submedian suture. Ninth sternite (H) suboctagonal, small; bearing a broad, sinuous, complex process (HP) which is apically emarginate, the left apical angle micro-echinulate. Above HP a very weakly sclerotized V-shaped structure of doubtful homology is present. Left cercus-basipodite (LCB) present ventrally as a broad free sclerite perhaps also as the outer half-ring sclerite fused to base of left cercus. Left cercus somewhat laterally compressed, sinuous; distal third faintly pigmented; margin above this, along inner half, densely micro-echinulate, not nodulose. Right cercus with basal segment strongly laterally compressed proximally, basal foramen elongate; terminal segment small, pale.

Female: Unknown.

Holotype: (Cat. No. 53979, U. S. N. M.) winged male on slide; taken in plant quarantine at Brownsville, Texas, January 16, 1937 (U. S. N. M. Coll.).

Dr. A. B. Gurney informs me that the specimen was intercepted in Gardenias which had arrived by air express from the central part of the state of Vera Cruz, Mexico, probably in the vicinity of El Fortin, a small town forty miles southwest of Vera Cruz where most such shipments originate.

This interesting species is named for Mr. Consett Davis, of New England University College, Armidale, N. S. W., Australia.

The process of the left hemitergite is peculiar in that it is very strongly folded ventrad along the outer side. This condition seems to also be present in *heymonsi*. The single, outwardly-curved claw of the process of the right hemitergite which does not overlap any tergal structure may be used as a means of distinguishing the species from its relatives.

Anisembia (Chelicerca) wheeleri (Melander)

(Figs. 29 and 30)

Olyntha wheeleri Melander, 1902, Biol. Bull., 3: 17, fig., 1.
Anisembia wheeleri Krauss, 1911, Zoologica, 23: 70; Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 346.
Haploembia wheeleri Enderlein, 1912, Coll. Zool. Selys Longch., 3: 70, 109. fig. 41.

Male:[12] Apterous. *Color* black. Length 6.5 mm.

[12]Description based on excerpts from the original as well as the writer's interpretation of figures of the holotype furnished by Mr. C. Davis.

Head (fig. 29) black; slightly larger than the terminalia, sides nearly straight gradually convergent; abruptly, broadly obtusely angulate across base; surface finely, evenly rugulose. Eyes rather small. Antennae with first and second segments piceous, remainder dark fuscous; twenty segments present (incomplete).

Terminalia (fig. 30): Tenth tergite with submedian suture entire to base; left hemitergite (10 L) small, process (10 LP) broad, short, bi-emarginate on outer side; right hemitergite (10 R) broad, process (10 RP) cleft at apex, inner process slender, talon-like, curved to right; outer process triangular, truncate, lying beneath the inner process. Ninth sternite broad, irregular, terminating behind in a small pointed process directed to the right. Left cercus stout, clavate, obliquely truncate at tip, densely echinulate along inner side in median third.

Female: Unknown.

Holotype: Apterous male (in alcohol) deposited in the Museum of Comparative Zoology; from Cuernevaca, Mexico, collected December 26, 1900, by Dr. W. M. Wheeler while excavating a nest of *Leptogenys wheeleri* Forel.

Anisembia (Chelicerca) heymonsi (Enderlein)

(Fig. 31)

Oligotoma heymonsi Enderlein, 1912, Coll. Zool. Selys Longch., 3: 114, figs. 74–76.
Anisembia (?) heymonsi Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 346.

Male: Winged, small. *Dimensions*—Length 5 mm.; fore-wing, length 4.5 mm. *Color*—Head and first antennal segment black; antennae brownish-yellow; prothorax rusty-yellow, its sternite and coxae brown; pterothorax, abdomen and legs black, cerci dark-brown; wings brown, hyaline stripes scarcely lighter than rest of wing, region bordering R_1 reddish-brown, membrane with traces of reddish luster.

Head rather small, sides behind eyes long (about three eye-diameters long), rather straight, somewhat convergent caudad; basal margin rounded. Eyes small, rather strongly convex. Antennae 16 to 17 segmented (incomplete?).

Wings moderately slender; no traceable cross-veins present between C and R_1 in both wings; R_1 abruptly terminating before margin; three cross-veins present between R_1 and R_{2+3} in the fore-wing, in the hind wing one; R_{4+5} (except in basal fourth), M and Cu_{1a} subobsolescent.

Terminalia (fig. 31) with left hemitergite (10 L) rather broad; process (10 LP) broad basally, acuminate, very narrow apically, outer margin of apex strongly bent ventrad. Right hemitergite (10 R) bearing caudally two claw-like outwardly-curved hooks; basal hook partially hidden beneath hind margin of 10 R; sutural margin emarginated, bearing an inwardly and caudally directed cone-like projection. Process of ninth sternite (HP) rounded apically, right hind margin bearing five (Enderlein figures four) short teeth; "hinten seitlich verschmilzt das 9. Sternit mit dem rechten Teil des 10. Tergites."[13] Left cercus long,

[13] I cannot visualize this character as illustrated in Enderlein's figure 75.

stout, somewhat curved; bearing a relatively large number of rather stout echinulations on inner side in apical half, some of these bear small lateral projections.

Holotype: Winged male, (deposited in the Berliner Zoologischen Museum) from Sierra Mixteca, MEXICO (C. A. Purpus).

The above description represents the writer's interpretation of Enderlein's original description and illustrations expressed in the style adopted in this paper.

The nature of the terminalia and other characters leaves little doubt that this species is an *Anisembia* and therefore that the left cercus is actually one-segmented. Enderlein claimed that the left cercus was two-segmented and that the terminal segment had broken off. In his figure and description he called attention to a small scar and stated that this represented the point of attachment of the lost segment. The writer suspects that this scar is but a small unpigmented area of the cercus which is often present in a similar position in certain other species of the genus.

Subgenus **Dactylocerca** Ross, new subgenus

Males: Head smaller than terminalia, narrow, elongate; eyes and mandibles very small. *Wings* as in *Chelicerca*. *Terminalia* with submedian suture of tenth tergite entire to base; process of left hemitergite (10 LP) small, narrow, thick, twisted; sutural margin of right hemitergite deeply incised by a narrow, longitudinal, membranous area; hemitergite not developed as an apical process and without apical hooks. Process of hypandrium (HP) large, broad, strongly rounded apically and fringed with echinulations; covered dorsally and ventrally by derm, hollow. Left cercus-basipodite (LCB) small, fragmentary, free. Left cercus greatly elongated, evenly curved inward; not nodulose or clavate; echinulations scattered on inner side of apex. Basal segment of right cercus as in *Chelicerca*.

Type: Anisembia (*Dactylocerca*) *rubra* new species.

Distribution: Arizona, Southern California and Northern Lower California.

Anisembia (**Dactylocerca**) **rubra** Ross, new species

(Figs. 35–37)

Male (on slide): *Color* (in alcohol)—Head, tenth tergite and hypandrium jet-black; antennae, legs and cerci smokey-black; thorax and abdomen brick-red tinged with brown; wings brown, narrow bands bordering R_1 red. *Dimensions*—Small; length, 6.7 mm.; fore-wing, length 3 mm., breadth, 0.75 mm.

Head (fig. 35) much smaller than terminalia, elongate; sides behind eyes straight, feebly convergent caudad, abruptly rounded behind. Eyes small, facets not large but each clearly outlined by pigmented rings. Mandibles small, short, black. Antennae with segments relatively large; 18-segmented when complete.

Wings small, narrow; R_1 gradually converging to costal margin and meeting it in apical fourth, region between costa and R_1 without cross-veins but pigmented red (appearing as granules) which continue as a narrow band along anal side of R_1 nearly to junction of radial sector; R_{2+3} pigmented to margin, one or two cross-veins present between it and R_1, this joining the latter near its apex; R_{4+5}, M and Cu_{1a} represented only by their pigment bands and rows of macrotrichiae, these are very sparse in hind wing; hyaline stripes very narrow, definite, those between R_{2+3} and R_{4+5} and M abruptly curved towards each other at their apices.

Terminalia (figs. 36 and 37) very large in relation to other body proportions. Tenth tergite complexly divided by a suture entire to its base to form two very unequal hemitergites; left hemitergite (10 L) small, process (10 LP) narrow, twisted, inner margin straight, outer margin arcuate proximally, acuminate distally; right hemitergite (10 R) very large, deeply incised near suture by a sinuous, longitudinal membranous area isolating a median area (10 RP_2) which is strongly sclerotized along sutural side and rugose terminally, remainder of 10 R broadly arcuate apically, not developed as a process, outer apical angle distinctly produced as a small point. Ninth sternite (H) broad, subsymmetrical basally; produced medially as a very large, broad, thumb-like process (HP) covered both dorsally and ventrally which is membranous in apical half opposite left cercus, bearing a fringe of minute tooth-like setae on opposite half. Left cercus-basipodite (LCB) present only in membrane of inner side of base of left cercus as a free, small, irregular, half-ring, dark sclerite. Left cercus tubular, very long, strongly, evenly, inwardly arcuate, bearing scattered, small echinulations on inner side of apex. Basal segment of right cercus long, laterally compressed, basal foramen elongate; terminal segment small, short, cylindrical.

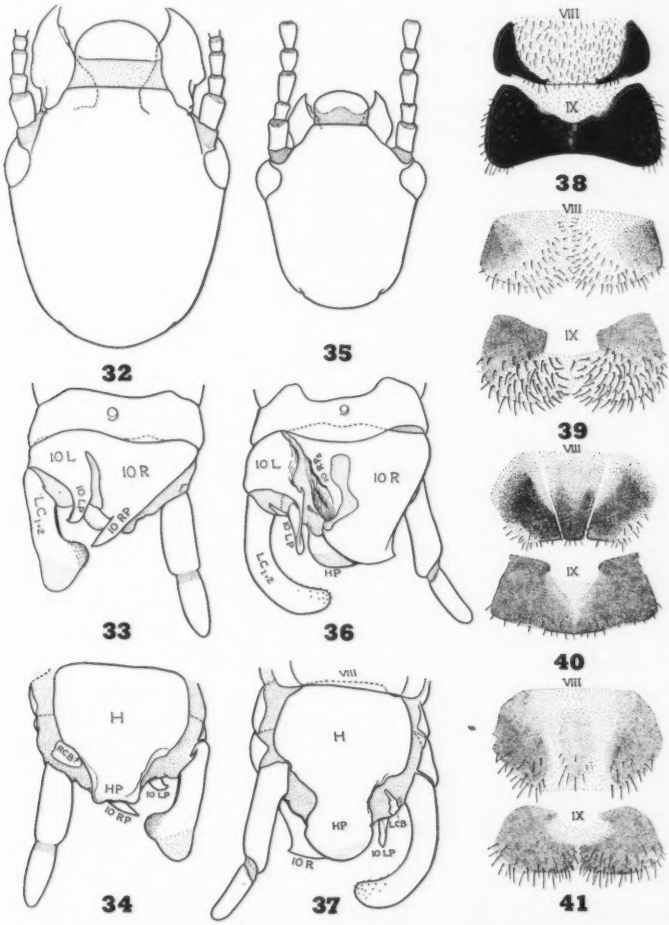
Apterous male: Unknown.

Female: Small. Color (in alcohol) brick-red throughout. Body length, 8 mm. Head narrow, elongate, without dorsal basal pattern; antennae 18-segmented. Eighth and ninth sternites similar to *texana*.

Holotype, male, on slide, (No. 4931, Calif. Acad. Sci., Ent.) and *allotype* female, on slide, (No. 4932, Calif. Acad. Sci., Ent.) and numerous paratypes of both sexes on slides and in alcohol, collected at Rosarito Beach, LOWER CALIFORNIA, MEXICO, April 3–5, 1939, by C. D. Michener and the writer, under stones on the sea-shelf very close to the ocean.

Although an ample series was obtained, specimens were not very abundant and the series was secured only after many hours of specialized collecting.

Distribution of paratypes: Institutions—California Academy of Sciences; U. S. National Museum; Museum of Comparative Zoology; Los Angeles County Museum; Snow Museum;



Figs. 32–34, *Anisembia* (*Bulbocerca*) *sini*, homotype male: fig. 32, head; fig. 33, terminalia (dorsal); fig. 34, terminalia (ventral). Figs. 35–37, *Anisembia* (*Dactylocerca*) *rubra*, holotype male: fig. 35, head; fig. 36, terminalia (dorsal); fig. 37, terminalia (ventral). Fig. 38, *Anisembia* (*A*) *texana*, eighth and ninth sternites of plesiotype female. Fig. 39, *Gynembia tarsalis*, sternites of holotype female. Fig. 40, *Oligotoma saundersii*, sternites of female. Fig. 41, *Oligotoma nigra* sternites of female. All figures drawn to scale (25 ×). (Explanation of symbols under figs. 5–13, p. 641.)

American Museum of Natural History; Cornell University; University of Arizona; Citrus Experiment Station, Riverside, California; University of California, Berkeley; San Diego Society of Natural History; British Museum of Natural History. Private collections—Consett Davis, C. D. Michener, G. E. & R. M. Bohart, A. D. Imms, D. G. Hale Carpenter, the writer.

Additional distributional records: CALIFORNIA—San Ysidro, April 2, 1939, (Ross and Michener), 1 ♀ under stone; Piñon Flats, San Jacinto Mts., June 27, 1939, (E. G. Linsley) 1 ♂ sweeping; same data, (J. G. Shanefelt) 1 ♂ sweeping; Palm Cyn., near Palm Springs, April 16, 1937 (G. E. & R. M. Bohart) 1 ♂ diurnal flight; same locality, April 9, 1939 (Ross and Michener) 1 ♂, 3 ♀ in skirts of native fan palms; Banning (D. W. Pierce) penult. ♂, under stones on desert. ARIZONA—Tucson, March 26, 1936 (E. D. Ball) 1 ♂; Santa Catalina Mts., May 14, 1937 (R. A. Flock) 3 ♂; Santa Rita Mts., June 21, 1936 (Flock) 1 ♂; same locality, 5–8000 ft., July (F. H. Snow) 1 ♂ (Snow Museum); Superior, May 22, 1937 (Ball) 1 ♂; Atascosa Mt., August 7, 1937 (Ball) 2 ♂. All Arizona specimens secured by sweeping and are from the Arizona University Collection except when otherwise indicated.

This small species was first brought to the writer's attention by the male specimen secured by G. E. and R. M. Bohart at Palm Canyon. It is one of the most striking known from this fauna and the accompanying figures should be sufficient to distinguish it from all others. The arcuate left cercus of the male is somewhat like that of ***heymonsi*** (End.), especially in certain variants, but the two species can be readily separated by the nature of the apex of the right hemitergite which is distinctly bifurcate in ***heymonsi*** and simple in ***rubra***. The reddish color of the females and young seems to be a peculiar feature. This, together with the small size, may be used as a superficial means of recognizing the species in the field.

The species seems to have a very wide ecological tolerance, ranging as it does from sea-level to at least 5,000 feet elevation, from moist, seasonally-foggy coastal regions to arid inland localities. It, however, seems to be quite discontinuously distributed within its general range. The writer has found that, unlike certain other species, it is never abundant in any one locality. The tunnels are delicate, seldom numerous and generally inconspicuously spun on the sides of the impression

made by the stone and are, therefore, perhaps very easily overlooked by the collector not searching for them. The individuals are unusually lively and readily escape. The males seem to have a diurnal activity as indicated by the frequency with which specimens have been collected by sweeping herbage, the fact that one specimen was secured in diurnal flight and that none have been collected at lights set out to attract them.

DISCUSSION OF THE GENUS ANISEMBIA

It is interesting to consider certain conclusions that may be based on a comparative study of the species of this genus. It must be admitted, however, that it is rather presumptuous at this early stage in our knowledge to generalize concerning a genus so poorly known. The writer is certain that more extensive collecting in Mexico will prove the existence of many interesting additional species as well as add to the knowledge of those already described (the three species from the Mexican mainland are known only by their unique male holotypes!).

In distribution *Anisembia* assumes the characteristic pattern of many other neotropical genera of animals and plants. It occurs not only in humid tropical regions but also in the northern arid Sonoran Deserts. In the latter regions the species seem to withstand the long hot dry seasons by retreating down soil-cracks, etc., to a depth of six inches or more.

The peculiar one-segmented left cercus of the male is a condition also present, by convergence, in the Australian genera *Notoligotoma* and *Metoligotoma* of Davis. The membranous, movable joint between the two segments of the more primitive left cercus would appear to inhibit the value of the appendage as a clasping organ during copulation. Thus it seems that the tendency has been to overcome this defect (through selection) by a lengthening of the basal segment with a corresponding decrease in volume of the terminal segment (ex. *Mesembia haitiana* Ross). In certain species of *Anisembia* (*texana*, *schwarzi* and *sini*) the terminal segment is no longer separated from the basal segment by a movable joint, but is still represented as a prominent submembranous apical lobe which is densely setose. These setae seem to correspond in form and number to those of the terminal segment of the right cercus. The prominent subapical inner nodule is undoubtedly homologous to that of the basal segment in *Mesembia* and many other genera. It, or its echinulations, seem to constitute a landmark

of the basal segment. Perhaps the most specialized left cercus is present in *rubra* in which almost all traces of the terminal segment have become lost as well as almost all vestiges of the inner nodule. This phenomenon can hardly be termed a fusion of two segments but actually seems to be an exchange of substance from the terminal segment into the basal with a resultant reduction of surface area of the former. The one-segmented cercus appears to be approximately of the same volume as the two-segmented right cercus.

The subgenera seem to fall into a phylogenetic series with *Anisembia* s. str. most primitive and most closely approximating the species of *Mesembia* (which appear to form an ancestral link between it and the more generalized South American species); *Bulbocerca* quite divergent and highly specialized but retaining the primitive type of one-segmented left cercus and *Chelicerca* very complex but intermediate in degree of specialization with *Dactylocerca*.

GENUS INCERTAE SEDIS

(Family relationship undeterminable)

Genus **Gynembia** Ross, new genus

Anisembia (?) Chamberlin, 1923, Proc. Calif. Acad. Sci., (4) 12: 344.
Oligotoma Banks, 1924, Bull. Mus. Comp. Zool., 65: 421, Pl. I, fig. 11 (*ex parte*).
Embia Essig, 1926, Insects of Western N. A., p. 122, figs. 72, 73 (*ex parte*).

Moderately large, parthenogenetic, North American Embioptera. Females and young with two hind basitarsal bladders.

Genotype: Gynembia tarsalis Ross, new species.
Distribution: California, Arizona.

Gynembia tarsalis Ross, new species

(Figs. 4 and 39)

Anisembia (?) *californica*, Chamberlin, l. c. (misidentification).
Oligotoma californica, Banks, l. c. (*ex parte*).
Embia californica, Essig, l. c. (*ex parte*).

Male: Unknown.

Female (on slide): *Color* light yellowish-brown throughout; head reddish-brown. *Length* 13 mm.

Head slightly longer than broad; sides very broadly arcuate, scarcely convergent caudal; broadly, evenly rounded behind; sparsely clothed with short setae; basal pattern present but faint. Submentum twice as wide as long; margins straight, corners square. Foramen magnum almost equilaterally triangulate; anterior angle acute, narrowly rounded.

Hind tarsus (fig. 4) with ventral setae of basitarsus stout, short, very dense, particularly along outer half; both bladders membranous, clear,

the basal bladder rather small, rounded. Bladder of second tarsal segment large, densely covered with minute echinulations.

Abdominal sternites: Eighth sternite (fig. 39) pigmented at sides only, gradually becoming clearly membranous medially. *Ninth sternite* (fig. 39) pigmented only in two lateral basal areas, abruptly membranous in median third and across entire apical half, this apical half clothed with unusually long, rather dense setae. The two sternites are each longitudinally divided medially by a region of weakness into two convex hemisternites.

Holotype, female, on slide, (No. 4934, Calif. Acad. Sci., Ent.) and numerous female paratypes on slides and in alcohol, collected by the writer under stones at Clayton, Contra Costa Co., CALIFORNIA, July 4, 1939.

Distribution of paratypes: Same as indicated for *Anisembia* (*Dactylocerca*) *rubra* Ross.

Additional records: CALIFORNIA—Auburn, Placer Co. (L. C. Christenson); Capay, Yolo Co. (B. E. White); Monticello, Napa Co. (Ross); Clayton, Lafayette and Berkeley, Contra Costa Co. (Ross); Niles Cyn., Livermore Hills, Alameda Co. (Ross); Palo Alto (C. Davis, Ross); Bryceburg, Mariposa Co. (Ross); Calabasas (Ross and Michener) and Westwood Hills (Stahler), Los Angeles Co.; Ojai, Ventura Co. (W. E. Simonds); Riverside (Simonds); Santa Ana (L. Gillogly); Vista (Gillogly), La Jolla (Ross and Michener), Adobe Falls (Moore, Harbison, Miller), San Diego, Chula Vista and San Ysidro (Ross and Michener), San Diego Co.; Avalon, Santa Catalina Island (Meadows). ARIZONA—Tempe (E. V. Walter).

For many years entomologists have noted the presence of this abundant species in California; particularly in the San Francisco Bay Region. It was assumed that it represented *Embia californica* Banks,[14] the only species described from California. In all these years no males have ever been collected in Northern California and it was this problem which attracted the writer to a study of the order.

A number of cultures of live immature individuals were obtained in the field at several localities in the state and kept for laboratory observation. To supplement these, studies were conducted in the field at frequent intervals. Upon the maturity of these individuals, eggs and young appeared in all the cultures as well as in the field without the presence of males. After carefully weighing all the evidence it has been concluded that the species is parthenogenic. This seems to be the first

[14]The actual identity of this species will be discussed later.

case of parthenogenesis reported in the order, although Vayssière (1934, p. 190) suggests the possibility that *Embia vayssierei* Navás of Africa may be parthenogenic.

Ordinarily it would be very difficult to distinguish such a species by the female alone, but fortunately *Gynembia tarsalis* has two hind basitarsal sole bladders, a character which appears in all instars and which clearly distinguishes it generically from all other known North American species.

It is most unfortunate that the relationship of the genus within the order cannot be established at this time due to the fact that any such conclusions must be based entirely on the characters of the mature male. It is hoped therefore that this case of parthenogenesis is of the type which permits an occasional male to appear.

The distinctive character of this genus as well as its apparent preference for areas of the state which possess a biota considered to be peculiarly Californian but largely of ancient derivation from the south, suggest that *Gynembia* may be a part of this biota. It is perhaps not related to *Anisembia*, certain species of which seem to be elements of the biota of the Sonoran deserts more recently derived from the neotropical fauna and flora.

The above distributional records indicate an extensive range throughout the state of California. The species seems to occur sporadically in the western foothills of the Sierra Nevada Mountain Range at least as far north as Auburn. In the Coast Range it occurs southward from the Clear Lake District to the Mexican border.

The individuals of the species seem to be active throughout the year except for short winter cold periods at which times they have been observed lying quiescent in completely enclosed cocoons of dense silk spun in the galleries in dry cattle droppings. The spring season is the most active period and maturity is nearly attained before the beginning of the dry season; about the first of June. At this time the individuals retreat down tunnels spun in soil cracks, etc., to a depth of about six inches in order to escape the summer heat and dryness. Here the eggs are laid and hatch soon thereafter. With the first fall rains in October (usually) the young (mostly at least in the third instar), and a few surviving females reappear at the surface and are active throughout the winter except when too cold.

The species is most apparent under stones but it has been discovered that it may also occur in open fields living at the base of dry grass and using soil cracks for retreats.

It has been collected in company with other species of the order in Southern California; for example, at La Jolla, it was found under the same stones with *Oligotoma nigra* Hagen and at San Ysidro, not only in company with *nigra*, but also with *Anisembia rubra* Ross.

INTRODUCED SPECIES

FAMILY OLIGOTOMIDAE

Genus **Oligotoma** Westwood

Embia (*Oligotoma*) Westwood, 1837, Trans. Linn. Soc. Lond. (Zool.), 17: 373, figs.
Oligotoma Burmeister, 1839, Handb. Ent., 2: 770.[15]

Males: Winged, with veins R_{2+3}, R_{4+5} and M simple, unforked; R_1 joining R_{2+3} before margin. *Head* with eyes large, inflated; mandibles elongate, the right with three inner apical dentations, the left with two. *Basitarsi* of hind legs with just the one terminal bladder. *Terminalia* with tenth tergite divided submedially by a suture which is generally abbreviated in proximal third; each hemitergite bearing processes, major process of right hemitergite (10 RP_1) large, generally long, V-shaped, partially overlying at base a smaller, medial, flaplike process (10 RP_2) the sclerotic portion of which has the same base as 10 RP_1. *Ninth sternite* (H) large, broad basally, elongated and tapered distally in a process (HP) directed toward left cercus; often bearing a sclerotic spine-like appendix apically, which is fused to the left side of HP. *Left cercus* two-segmented, basal segment tubular, occasionally lobed on inner side but never echinulate. *Left cercus-basipodite* (LCB) free, prominent, ring-like; often produced and specialized mesad.

Females: Too imperfectly known for analysis of possible generic characters. Hind basitarsi with but one bladder.

Genotype: Oligotoma saundersii (Westwood).

Distribution (after Davis, 1939a): "East Africa through India and China to Southern Japan, the Philippines, the East Indies, New Guinea, Australia and Tasmania, and some islands in the Indian Ocean." None are native to the New World as commonly believed, but three species have been introduced in man's commerce and have since become well established in certain areas.

The oligotomoid venation, the two-segmented left cercus with its non-echinulate basal segment together with the long

[15]Complete bibliography omitted.

V-shaped major process of the right hemitergite will serve to distinguish this from the other North American genera.

The three species occurring in this fauna seem to be relatively common wherever they occur and the males are most frequently collected attracted to lights.

KEY TO NORTH AMERICAN SPECIES OF OLIGOTOMA

1. Major process of right hemitergite (10 RP_1) with a small but distinct subapical tooth on outer margin.....(3) **humbertiana**
   Major process without such a tooth.....2
2. Process of left hemitergite (10 LP) broad, only about twice as long as broad. Sclerotic spine of hypandrium-process long, slender, sickle-shaped; lying horizontal beneath process (HP).....(1) **saundersii**
   Process of left hemitergite slender, about five times longer than broad. Sclerotic spine of hypandrium-process short, stout, hook-like; bent ventrad, (2) **nigra**

(1) **Oligotoma saundersii** (Westwood)

(Figs. 40, 42–44)

Embia (*Oligotoma*) *saundersii* Westwood, 1837, Trans. Linn. Soc. Lond. (Zool.), 17: 373, pl. II, fig. 2.

Oligotoma saundersii Burmeister, 1839, Handb. Ent., 2: 770; Walker, 1853, List Neurop. Brit. Mus., p. 531; Waterhouse, 1881, Ann. Mag. Nat. Hist., (5) 8: 436; Conry, 1881, ibid., p. 346; Wood-Mason, 1883, Proc. Zool. Soc. Lond., p. 628; Hagen, 1885, Can. Ent., 17: 144; Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 181 (establishes actual identity).

Embia latreillii Rambur, 1842, Hist. Nat. Neurop., p. 312; Lucas, 1883, Bull. Soc. Ent. France (6) 3: XXVI, CVI.

Oligotoma latreillii (*latreillei*) Enderlein, 1910, Trans. Linn. Soc., (2) 14: 56; Enderlein, 1912, Coll. Zool. Selys Longch., 3: 74; Rimsky-Korsakow, 1914, Ent. Mitt., 3: 179; Navás, 1918, Broteria, 16: 91; Friederichs, 1923, Capitata Zool., 2: 7; Okajima, 1926, Journ. Coll. Agric., Imper. Univ., Tokyo, 7: 422; Navás, 1929, Rev. zool. bot. Africa, 18: 109; Navás, 1929, Ann. Mus. Storia Nat., Genova, 53: 388; Friederichs, 1934, Arch. Naturg., 3: 413; Mukerji, 1935, Rec. Ind. Mus., 37: 8; Davis, 1936, Proc. Linn. Soc. N. S. W., 61: 243; Davis, 1938, ibid., 63: 254; Davis, 1939, ibid., 64: 183 (establishes syn.).

Olyntha cubana Hagen (*nomen nudum*), 1866, Verh. Zool. bot. ges., Wien., 16: 221, 223; M'Lachlan, 1877, Journ. Linn. Soc. (Zool.), 13: 381.

Oligotoma cubana Hagen, 1885, Can. Ent., 17: 141; Krauss, 1911, Zoologica, 23: 44; Davis, 1939, l. c., p. 183 (establishes syn.).

Oligotoma insularis M'Lachlan, 1883, Ann. Mag. Nat. Hist., (5) 12: 227; Blackburn, 1883, ibid., 14: 413; Hagen, 1885, Can. Ent., 17: 143; Perkins, 1897, Ent. Monthly Mag., 33: 56; Perkins, 1899, Fauna Hawaiiensis, 2: 88; Friederichs, 1906, Mitt. Zool. Mus., Berlin, 3: 236; Krauss, 1911, Zoologica, 23: 40; Navás, 1918, Broteria (Zool.) 14: —; Bryan, 1926, Bull. Bishop Mus., 31: 91; Mills, 1932, Ann. Ent. Soc. Am., 25: 652; Bryan, 1933, Proc. Hawiaian Ent. Soc., 8: 239, 246; Friederichs, 1934, Arch. Naturg., 3: 413; Friederichs, 1935, Occ. Papers Bishop Mus., 11: 3; Davis, 1939, l. c., p. 183 (confirms syn.).

Embia bramina de Saussure, 1896, Mitt. Schweiz Ent. Ges., 9: 352.

Oligotoma bramina, Krauss, 1911, Zoologica, 23:—; Davis, 1939, l. c., p. 184 (suggests syn.).

Embia hova de Saussure, 1896, Mitt. Schweiz Ent. Ges., 9: 354; Verhoeff, 1904, Nov. Act. Leop.-Carol Akad., 82: 202; Friederichs, 1907, Voeltzkow, Reise in Ostafrika Stuttgart, p. 51.

Oligotoma hova Krauss, 1911, Zoologica, 23: 38; Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 183 (as a syn.).

Oligotoma rochai Navás, 1917, Ent. Mitt., 6: 281; Krauss, 1917, ibid., p. 316 (estab. syn.); Davis, 1939, l. c., p. 184.

Oligotoma inaequalis Banks, 1924, Bull. Mus. Comp. Zool., 65: 421; Davis, 1939, l. c., p. 184 (estab. syn.).

This species has been adequately described several times under the name *latreillei* (Ramb.), (Enderlein, 1912; Okajima, 1926; Davis, 1936). Therefore a detailed description at this time is unnecessary. The following notes[16] will be found sufficient to distinguish it from related species.

Male: Color light brown, head and terminalia darker. *Length*—9 mm.; fore-wing, length 5.75 mm.; breadth, 1.5 mm.

Terminalia (figs. 43 and 44) with process of left hemitergite (10 LP) broad, thin, slightly constricted basally but swollen subapically, sides arcuate, tip abruptly, narrowly acuminate; process of right hemitergite (10 RP_1) long, gradually, evenly acuminate distad, extreme apex hooked to right, subtended by a smaller sharp projection. Ninth sternite (H) broad, transverse basally; asymmetrically produced towards left cercus as a broad process (HP) with a horizontal sclerotic appendix fused to its left apical angle, which extends to the right beneath as a narrow sickle-shaped spine and to the left as a short, minutely-bifurcate projection. Left cercus-basipodite (LCB) free, ring-like, broadest ventrally; produced mesad as a narrow, simple, rounded lobe. Basal segment of left cercus cylindrical, not nodulose on inner side.

Female: Color chocolate-brown throughout. *Length* 12 mm. *Eighth sternite* (fig. 40) divided into a medial and two lateral pigmented areas by two narrow, caudally convergent membranous lines. *Ninth sternite* (fig. 40) incised medially by a V-shaped unpigmented area almost to posterior margin.

Type: Male (mounted on card, terminalia on slide), deposited in the Hope Department of Entomology, Oxford University, from East India, collected by W. S. Saunders.

Davis (1939a) has redescribed and illustrated this type. His examination indicated very conclusively that this species has been incorrectly named *latreillei* (Rambur) by many authors for at least twenty-seven years and that the name *saundersii* has been applied to an entirely distinct species which now will take the name *humbertiana* (de Saussure). Since these two are perhaps the most abundant and most wide-spread species of the order, this clarification of names is of great significance.

This species, like its relatives in the Americas, has undoubtedly been introduced to this continent through commerce. It is probably relatively abundant in many localities in North America although it has never been recorded by American writers in spite of its occurrence within the borders of the United States. Like many introduced insects it has been mistakenly described as a native species, e. g., *O. cubana* Hagen, and *O. inaequalis* Banks, both from the West Indies.

[16]Based on a specimen from Biscayne Bay, Florida.

World distribution: Artificially tropicopolitan.

North American Records: FLORIDA, Biscayne Bay (U. S. N. M.), 1 male; Wiecsdale, April 24, —, (C. H. Paige), (M. C. Z.) 1 male; Orlando, August, 1927, (O. C. McBride), (U. S. N. M.) 4 males at trap light; Orlando, October 10, 1933, (G. H. Bradley) (U. S. N. M.) 2 males; Key West (Morrison Coll.), (U. S. N. M.) 2 males; TEXAS, Galveston, June 8, 1910, (D. K. McMillan), (D. W. Pierce Coll.) 2 males and 2 females in flour mill; MEXICO, males and females intercepted at Brownsville in seed cotton (U. S. N. M.), Apaseo, 1 male (intercepted at Laredo November 17, 1936), (U. S. N. M.), WEST INDIES, St. Croix (type of *inaequalis* Banks) 1 male; Cuba (type of *cubana* Hagen) also recorded as *insularis* McL.

Saundersii can be distinguished from the two following species by means of its broad cultriform process of the left hemitergite and the long, slender, sickle-shaped spine extending horizontal beneath the broad apical tip of the process of the ninth sternite. It may be further distinguished from *humbertiana* by the absence of the distinct subapical tooth on the outer side of the major process of the right hemitergite which is present in *humbertiana*.

(2) **Oligotoma nigra** Hagen

(Figs. 3, 41, 45–47)

Embia nigra Hagen (*nomen nudum*), 1866, Verh. Zool. Bot. Ges., Wien; Friederichs, 1906, Mitt. Zool. Mus., Berlin, 3: 237.

Oligotoma nigra Hagen, 1885, Can. Ent., 17: 174[1]; Krauss, 1911, Zoologica 23: 41; Werner, 1912, Vienna Sitz. Acad. Wiss. Math. Klasse, 121 (1): 176, fig.[2]; Enderlein, 1912, Coll. Zool. de Selys Longchamps, 3: 86, figs.[3] Silvestri, 1923, Trans. Ent. Soc. Lond. 1923; 261[4]; Friederichs, 1934, Archiv. Naturg., N. F., 3: 414, et seq., figs.[5]; Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 188.

Embia californica Banks (new synonym), 1906, Trans. Am. Ent. Soc., 32: 1, pl. I, fig. 1; Krauss, 1911, Zoologica, 23: 70; Enderlein, 1912, Coll. Zool. Selys Longch., 3: 53 (*Embia* ?); Essig, 1926, Ins. Western N. A., p. 122, figs., *ex parte*.

Oligotoma californica Banks, 1924, Bull. Mus. Comp. Zool., 65: 421, fig. *ex parte*; Navás, 1922, Rev. Acad. Ci. Zaragoza, 7: —. (misidentification).

Oligotoma saundersii Needham, 1909, Rec. Ind. Mus., 3: 193, fig. 11 (misidentification; Needham's figure indicates that this is perhaps actually *nigra*).

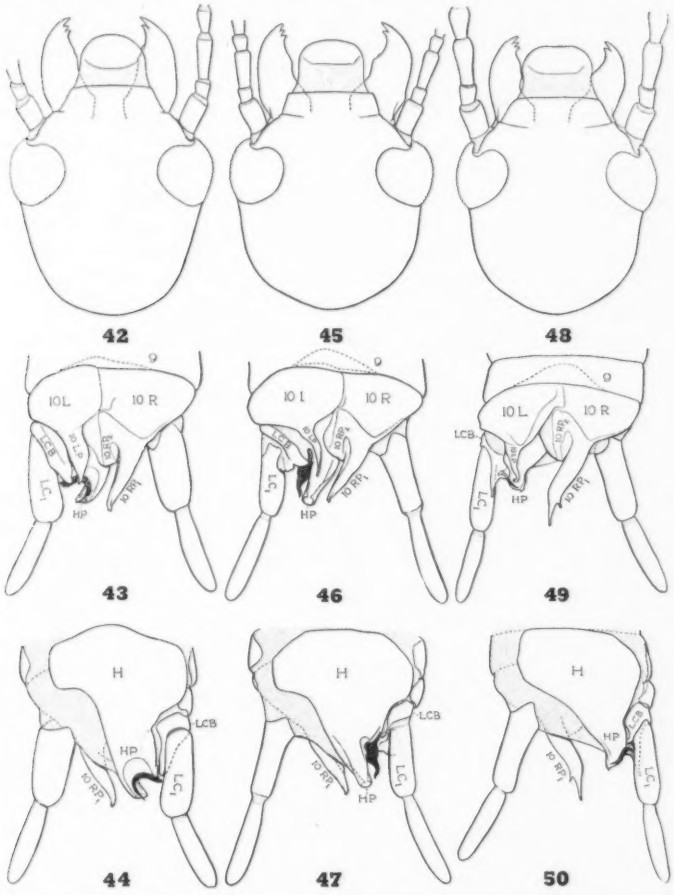
Oligotoma mesopotamica Esben-Petersen, 1929, Ent. Monthly Mag., (3) 15: 8, fig.[6]; Morton, 1929, ibid., p. 43 (suggests syn. of *nigra*); Esben-Petersen, 1929, ibid., p. 258 (claims validity); Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 188 (confirms syn.).

This species although very abundant in southwestern United States is recorded here for the first time as occurring in the New World.

Male: Color—Head very dark chestnut-brown; body, legs and pigmented portions of wings various lighter shades of chestnut-brown. *Dimensions*—Body, length 8.5 to 10.0 mm.; fore-wing, length 5.0 to 6.0 mm.; breadth, 1 to 1.25 mm.

Head (fig. 45) quadrate-oval, one-half longer than broad; sides straight, gradually converging caudad. Eyes moderately large, inflated. Antennae at least 20-segmented.

Terminalia (figs. 46 and 47) with left hemitergite (10 L) very dark, abruptly bearing a small, very slender, sinuous, straw-yellow process (10 LP) which is narrowly acuminate and twisted apically; right hemi-



Figs. 42–44, *Oligotoma saundersii*, male from Biscayne Bay, Florida: fig. 42, head; fig. 43, terminalia (dorsal); fig. 44, terminalia (ventral). Figs. 45–47, *Oligotoma nigra*, male from Palm Springs, Calif.: fig. 45, head; fig. 46, terminalia (dorsal); fig. 47, terminalia (ventral). Figs. 48–50, *Oligotoma humbertiana*, male from Guaymas, Mexico: fig. 48, head; fig. 49, terminalia (dorsal); fig. 50, terminalia (ventral). All figures drawn to scale (20 ×). (Explanation of symbols under figs. 5–13, p. 641.)

tergite (10 R) much lighter in color, process (10 RP_1) dark, gradually, evenly narrowed caudad, hooked slightly to right at extreme apex. Ninth sternite (H) broad, transverse basally, abruptly narrowed and produced caudad toward left cercus as a process which is somewhat tubular at apex (opening of ejaculatory duct); bearing a characteristic stout, heavily sclerotized appendix attached basally to left side, this is bulbous at base but abruptly tapered and hooked downward distally, a small dorsally-projected finger-like process of this is visible from above to the left of 10 LP. Left cercus-basipodite (LCB) produced mesad, bilobed; basal lobe narrow, partially overlying spine of HP; terminal lobe somewhat membranous, broadly rounded, overlapping a small inner basal portion of left cercus. Basal segment of left cercus simple, tubular.

Female: Color very dark chocolate-brown throughout; head somewhat lighter especially in clypeal region. *Length*—10 mm. *Eighth sternite* (fig. 41) with two indefinitely-outlined, broad, round, lateral pigmented areas separated medially by an almost unpigmented area which becomes lighter towards base. *Ninth sternite* (fig. 41) with a median, narrowly-transverse membranous area in basal half; divided to apex by a very narrow lightly pigmented line.

Hagen's type series is deposited in the Museum of Comparative Zoology.[17] It consists of four males (three carded, one pinned) and two females (carded); the females and one of the males are from the Island of Rhoda near Cairo, Egypt, the remainder are from "Upper Egypt, Jan. 1852," all were collected by Prof. Schaum. The Cairo male (carded) bears the type number 155, it has been labelled lectotype by Davis.

Early in the course of the writer's studies in the order numerous examples of this species from Arizona and Southern California were received. Subsequent study in co-operation with Mr. Davis indicated quite strongly that the specimens represent *Oligotoma nigra* Hagen, previously known only from Egypt and neighboring regions. Later Davis had the opportunity to compare some of these Arizona and California specimens with Hagen's types during his visit at Cambridge; they proved to be unquestionably conspecific with it.

The fact that the distribution of this species in America is closely correlated with the areas in which the Date Palm has been introduced by cuttings from North Africa and Persia (where *nigra* occurs) suggests that this was its avenue of introduction into North America. Further support of this possibility lies in the fact that the species generally constructs its colonies among the leaf bases and basal offshoots of the trunk

[17] I am indebted to Mr. Consett Davis for the facts relating to this series as well as for camera lucida drawings of the lectotype.

of the Date Palm both in Egypt (Friederichs, 1934) and in America (writer's observations). Also Dr. T. D. A. Cockerell informs me (in litt.) that he and Nathan Banks collected Embioptera "years ago" in Date Palm cuttings which were being held at Washington, D. C., before being sent on to the Southwest for propagation.[18]

The introduction of this species thus occurred, probably as early as 1889 before the advent of strict quarantine laws.[19]

The writer is convinced that *Embia californica* Banks, described in 1906 from three penultimate males collected near Los Angeles, California, is a synonym of *nigra*, although specific identity is difficult to ascertain without mature examples. However, to make conditions of comparison equal, a penultimate male of *nigra* in alcohol, obtained in a laboratory culture from La Jolla, California, which produced mature males of *nigra*, was sent to Dr. Banks to be compared with his types. He replied that my specimen was so similar to the types that he could find no differences.

There is little likelihood that *Anisembia rubra* Ross, the only other known winged species occurring near the type locality of *californica*, could be Bank's species. Its penultimate males are much smaller and characteristically entirely brick-red in color as compared with the "pale-yellowish-brown" color of the types of *californica*. It further seems unlikely that the types represent the undiscovered males of *Gynembia tarsalis* as Dr. Banks has informed me that his types have only one hind basitarsal bladder.

Later (1924) Banks transferred *californica* to the genus *Oligotoma* on the basis of mature examples then at hand. These mature examples perhaps were actually *nigra*. The females also mentioned and illustrated by him at the same time will probably prove to be those of *Gynembia*.

World distribution: Egypt[1, 2, 3, 5], Irak[4, 6], Palestine[5], Southwestern United States.

North American distribution: ARIZONA, Higley (E. G. Holt); Tucson (F. M. Carpenter), (R. A. Flock); Maricopa Co. (R. H. Beamer); Phoenix (J. C. Bradley), (R. A. Flock); Tempe (E. V. Walter); Yuma (R. C. Dickson). Records based on

[18]Melander (1903, p. 101) probably refers to this same observation. He states that the nymphs collected were *maurilanica*; they were probably in reality *nigra*.

[19]It will be recalled that two important scale insects were also introduced on the Date Palm during this period, namely, *Parlatoria blanchardi* (Targ.) and *Sphaerococcus marlatti* (Ckll.).

numerous males collected at light from April to September. CALIFORNIA, Blythe (P. H. Timberlake); El Centro (R. H. Beamer), (D. W. Pierce) on date palm; El Centro, young in bark of Canary Island Palms in city park (Ross and Michener); Holtville (P. W. Oman); Mecca, young in Date Palm (D. W. Pierce); Indio (J. C. Bradley), (Ross); Indio, young on Date Palm (Ross and Michener); Palm Springs (Ross); San Ysidro, males, females and young under stones on grassy hillside (Ross and Michener); La Jolla, April 2, 1939, males, females and young under stones and Canary Island Palm debris (Ross and Michener). Unless otherwise indicated the California records are based on males collected at lights during June and July. TEXAS, Victoria, Dec., 1920 (J. C. Bridwell) 3 males.

Distinguishable from *saundersii*, its closest relative, by the very slender, somewhat obscure process of the left hemitergite and the stout, ventrally-directed hook (often turned horizontal in crushed preparations) which is apically separated from, but parallel to, the narrow process of the ninth sternite; and from *humbertiana* by the same character as *saundersii*.

The published figures of the terminalia of *nigra* have all been unsatisfactory. Werner (1911, fig. 4) illustrates a crushed preparation almost from a caudal aspect, 10 LP is poorly represented; Enderlein's (1912, fig. 59) indicates that his specimen was badly crushed; Esben-Petersen (1929a, fig. 2, as *mesopotamica*) and Friederichs (1934, fig. 4) fail to indicate 10 LP.

(3) **Oligotoma humbertiana** (de Saussure)

(Figs. 48–50)

Embia humbertiana de Saussure, 1896, Mitt. Schweiz Ent. Ges., 9: 353.
Oligotoma humbertiana Davis, 1939, Proc. Linn. Soc. N. S. W., 64: 186, fig. 5.
Oligotoma saundersi (or *saundersii*) Krauss, 1911, Zoologica, 23: 39; Enderlein, 1912, Coll. Zool. Selys Longch., 3: 78; Silvestri, 1912, Tijschrift voor Ent., 55: 333; Rimsky-Korsakow, 1914, Ent. Mitt., 3: 177; Navás, 1918, Broteria, 16: 91; Navás, 1918, Mem. Acad. Ci. Artes, Barcelona, 14: 361; Friederichs, 1923, Capitata Zool., 2: 4; Okajima, 1926, Journ. Coll. Agric., Imperial Univ., Tokyo, 7: 421; Esben-Petersen, 1928, Ann. Mag. Nat. Hist. (10) 1: 450; Navás, 1929, Ann. Mus. Storia Nat., Genova, 53: 388; Friederichs, 1934, Archiv. Naturg., 3: 414; Ling, 1934, Peking Nat. Hist. Bull., 9: 133; Ling, 1935, ibid., p. 261; Mukerji, 1935, Rec. Ind. Mus., 37: 8. (all misidentifications).
Oligotoma californica Navás, 1922, Rev. Acad. Ci. Zaragoza, 7: —. (misidentification vide Davis, 1939).

This species has been frequently well described and illustrated under the name *saundersii*. Ling's illustrations (1934, 1935) are particularly good.

Male: Color yellowish-brown, terminalia darker; head straw-yellow. *Length*—10.5 mm.; fore-wing, length 6.2 mm., breadth 1.7 mm.

Terminalia (figs. 49 and 50) with left hemitergite (10 L) narrowly, strongly sclerotized along sutural margin, process (10 LP) small, very narrow sinuous, acuminate, apex abruptly hooked to left and minutely bifurcate; process of right hemitergite (10 RP_1) very long, narrow, slightly sinuous, sides subparallel, tip directed straight back, abruptly narrowed, bearing an important small, distinct subterminal tooth on outer side. Ninth sternite (H) broad basally but gradually narrowed caudad, forming a broad process (HP) directed toward left cercus and beneath 10 LP; bearing a small sclerotic horizontal, spine-like appendix which is pointed at both ends. Left cercus-basipodite (LCB) produced dorso-posterio-mesad as a double lobe; basal portion blunt, rounded, closely approximating 10 LP, the terminal portion narrow, acuminate, closely paralleling inner side of basal half of left cercus. Basal segment of left cercus tubular, simple.

Female: None available for study.

Type: Male, in the Geneva Museum, from Ceylon.

Davis (1939a) has assigned the name *humbertiana* to this species which has been long incorrectly identified as *saundersii* Westwood. We owe our knowledge of the identity of *humbertiana* to Krauss (1911) who illustrated de Saussure's type but relegated the species to the synonomy of *saundersii* as then incorrectly known in the absence of the knowledge of the true identity of Westwood's type.

This species has been widely dispersed by human transport throughout the warm regions of the world. Although it is known in North America only from Western Mexico, further collecting will probably prove it to be more widely distributed.

World distribution: Artificially tropicopolitan.

North American Records: MEXICO—San Jose de Guaymas, Sonora, April 10, —, (L. O. Howard), (U. S. N. M.), 2 males; Indian Village, Maria Madre I., Tres Marias Isles, May 21, 1925 (H. H. Keiffer), (C. A. S.), 1 male; La Paz, Lower California, 1914, (L. Diguet), (Paris Mus.) males, as *californica;* (see Davis, 1939: 187); Atoyac de Alvarez, Mex., August 28, 1932 (W. V. Hagen), (A. M. N. H.), 2 males.

SELECTED BIBLIOGRAPHY

Banks, N. 1906. Descriptions of New Nearctic Neuropteroid Insects, Trans. Amer. Ent. Soc., 32: 1–120, pl. I.

1924. Descriptions of New Neuropteroid Insects. Bull. Mus. Comparative Zool., 65: 421–455, 4 pls.

Chamberlin, J. C. 1923. A Revision of the Genus Anisembia, with Description of a New Species from the Gulf of California. Proc. Calif. Acad. Sci., (4) 12: 341–351, figs.

Crampton, G. C. 1928. Anatomical Evidence that *Cylindracheta* is a gryllotalpoid, not an Embiid. Ent. Mitt., Berlin, 17: 252–257, 1 pl.

Davis, C. 1936. Studies in Australian Embioptera, Part I. Proc. Linn. Soc. N. S. W., 61: 230–253, 6 figs.

Davis, C. 1936b. Studies in Australian Embioptera, Part II, Ibid., pp. 254–258, 7 figs., 1 pl.

1938. Studies in Australian Embioptera, Part III: Revision of the Genus *Metoligotoma*, with description of new species, and other notes on the Family Oligotomidae. Ibid., 63: 226–272, 120 figs.

1939a. Taxonomic Notes on the Order Embioptera I: The Genotype of *Oligotoma* Westwood. Ibid., 64: 181–190, 5 figs.

1939b. Taxonomic Notes on the Order Embioptera II: A New Neotropical Genus of Embioptera. Ibid., pp. 217–222, 21 figs.

1939c. Taxonomic Notes on the Order Embioptera XIV: The Identity of *Embia ruficollis* de Saussure and of *Oligotoma venosa* Banks. Ibid., pp.—, 7 figs.

1940. Taxonomic Notes on the Order Embioptera XV: Notes and Corrigenda. Ibid. 65:—.

Eltringham, H., and **Hamm, A. H.** 1928. On the Production of Silk by species of the genus *Hilaria* Meig. (Diptera). Proc. Royal Soc. London (B) 102: 327–338, 1 pl., 3 figs.

Enderlein, G. 1912. Embiidinen Monographisch Bearbeitet, Coll. Zool. Selys Longch., 3: 1–121, 76 figs., 4 pls.

Esben-Petersen, P. 1929. Embioptera from Bagdad. Ent. Monthly Mag., (3) 15: 7–9, fig. 2.

Essig, E. O. 1926. Insects of Western North America, Macmillan Co., Chapter X, figs.

Friederichs, K. 1934. Das Gemeinschaftsleben der Embiiden und Naheres zur Kenntnis der Arten. Archiv. Naturg., 3: 405–444, figs.

Hagen, H. A. 1885. Monograph of the Embidina. Can. Ent., 17: 141–155, 171–178, 190–199, 206–229.

Imms, A. D. 1913. On *Embia major*, sp. nov., from the Himalayas. Trans. Linn. Soc. Lond. (Zool.), (2) 11: 167–195, figs., 3 pl.

Kershaw, J. C. 1914. The Development of an Embiid. London J. R. Micros. Soc., 1914: 24–27, pls. 3–4.

Krauss, H. A. 1911. Monographie der Embien. Zoologica von Chun 23: 1–78, 7 figs., 5 pls.

Ling, S. W. 1934. Notes on the Biology and Morphology of *Oligotoma* sp. Peking Nat. Hist. Bull., 9: 133–139, pl.

1935. Further Notes on the Biology and Morphology of *Oligotoma saundersii* Westw., ibid., pp. 261–272, pl.

Melander, A. L. 1902. Two New Embiidae. Biol. Bull., 3: 16–26, 4 figs.

1903. Notes on the Structure and Development of *Embia texana* Mel., ibid., 4: 99–118.

Mills, H. B. 1932. The Life History and Thoracic Development of *Oligotoma texana* (Mel.) (Embiidina) Ann. Ent. Soc. Amer., 25: 648–652, 4 figs.

Mukerji, S. 1927. On the Morphology and Bionomics of *Embia minor* sp. n., with Special Reference to its Spinning Organs. Rec. Ind. Mus., Calcutta, 29: 253–282, 1 pl., 10 figs.

Myers, J. G. 1928. The First Known Embiophile, and a New Cuban Embiid. Bull. Brooklyn Ent. Soc., 23: 87–90, 1 fig.

Navas, L. 1918. Embiopteros de la America meridional. Broteria, Braga, 16: 85–110, figs.

Okajima, G. 1926. Desc. of a new species of *Oligotoma* from Japan together with some notes on the Family Oligotomidae (Embiidina), Fourn. Coll. Agric., Tokyo, 7: 411–432, 2 pls.

Saussure, H. 1896. Note sur la tribu des Embiens. Mitt. Schweiz Ent. Ges., 9: 339–355, pl. 1.

Schwarz, E. A. 1888. (Note on Biology of *Oligotoma hubbardi* Hagen) Proc. Ent. Soc. Washington, 1: 94.

Snodgrass, R. E. 1937. The Male Genitalia of Orthopteroid Insects, Smithsonian Misc. Coll., 96: 1–107, 42 figs.

Vayssière, P. 1934. Sur un Embia nuisable en Afrique occidentale francaise. Bull. Soc. Ent. fr., Paris, 39: 188–191, pl.

Werner, F. 1912. Ergebnisse der mit Subvention aus der Erbschaft Treill unternommenen zoologischen Forschungsreise Dr. Franz Werner's nach dem ägyptischen Sudan und Nord-Uganda, Part XX Embidaria. Sitz. Akad. Wiss. Math.-Nat. Klasse, 121 (1): 176–179, fig. 4.

FAMILY CLASSIFICATION OF THE ORDER EMBIOPTERA[1]

CONSETT DAVIS,
Lecturer in Biology, New England University College,
Armidale, New South Wales

Recent revision of the Order Embioptera has necessitated a reconsideration of the grouping of the genera under family headings. Up to the present, six families have been recognized. The present paper adds two more, and briefly indicates the supposed evolutionary trends on which the revised family classification is based.

Suborder **PROTEMBIOPTERA** nom. nov.[2]

Protembiaria Tillyard, 1937, Amer. Journ. Sci., 33: 251.

Characters and distribution as for the single family.

Family **PROTEMBIIDAE** Tillyard

Protembiidae Tillyard, l. c., p. 251.

Genera: Protembia Tillyard, l. c., p. 251 (Permian of Kansas); *Tillyardembia* Zalessky, 1937, Nature, 140 (no. 3550) (Permian of Russia).

Little is known of the structure of these Permian genera. The venation appears to have been little reduced, and the cerci probably multi-articulate. Evidence as to the presence of the glands of the fore-tarsi, and the loss of wings in the female, is inconclusive.

The Carboniferous fossil *Megagnatha* Bolten is not considered to belong to this order.

Suborder **EUEMBIOPTERA** nom. nov.[2]

Euembiaria Tillyard, l. c., p. 251.

This suborder contains all Tertiary and Recent genera of Embioptera. The cerci are composed of less than three seg-

[1]Communicated by E. S. Ross.

[2]Tillyard used the ordinal form Embiaria, and his subordinal names Protembiaria and Euembiaria are modified to agree with the form Embioptera here adopted.

ments; spinning glands are present in the first segment of the fore-tarsus; the females are always wingless; the venation is more or less reduced in the males, the wings sometimes being absent in both sexes.

The male terminalia form the most reliable criterion for phylogenetic study and family classification, the venation being of secondary value. Convergence is frequent both in specialization of the terminalia and in the reduction of the venation, and consequently distribution is as important a consideration in classification as is morphology.

Family **CLOTHODIDAE** Enderlein

Clothodinae Enderlein, 1909, Zool. Anz., 35: 176 (subfamily of Embiidae).
Olynthidae Krauss, 1911, Zoologica von Chun, 23: 60.
Clothodidae Tillyard, 1937, Amer. Journ. Sci., 33: 251.

The family *Olynthidae* Krauss was based on a misidentification, but seems to have been intended to have much the same limits as the Clothodidae in the present sense. The genotype of *Olyntha* Gray (Griffith and Pidgeon Edition of Cuvier's Animal Kingdom, 15 [Insects, 2]: 347) is a member of the family Embiidae s. str., and in any case *Olyntha* is a homonym.

Genus: Clothoda Enderlein, 1909, Zool. Anz., 35: 176 (=*Antipaluria* Enderlein, 1912, l. c., p. 63, vide. Davis, 1939b, Proc. Linn. Soc N. S.W., 64: 379).

Distribution: Recent: South America (Brazil to Colombia and Trinidad). Tertiary: ? Miocene, Florissant of Colorado.

Most primitive of recent Embioptera, *Clothoda* has more reduced venation than that of the Protembioptera . . . with respect to the media, more reduced than some of the Embiidae s. str. The male terminalia are very simple, the cerci symmetrical, with two smooth segments, and the ventral structures almost symmetrical, and not greatly modified from the larval form.

Family **EMBIIDAE** Burmeister

Embidae Burmeister, 1839, Handbuch der Entomologie, 2: 768.[3]
Embiidae Enderlein, 1909, Zool. Anz., 35: 176.[3]

This family is herein restricted to the inclusion of those genera in which the males, if winged, retain the veins R_4 and R_5 distinct, and in which the terminalia have reached a common

[3]Complete bibliography omitted.

level of development . . . the first segment of the left cercus clavate and echinulate, the second segment still distinct and cylindrical, the tenth abdominal tergite completely cleft to base forming two distinct hemitergites. It is probably a polyphyletic group, the twenty genera included having reached corresponding stages in evolution, though not necessarily on the same line of descent. Our present knowledge does not allow any further subdivision into families or even subfamilies.

In addition to the type genus *Embia* Latreille, 1829, (in Cuvier, Le Règne animal, 2nd édit., 1829, p. 256, footnote), distribution, Mediterranean Region to South Africa, with wingless as well as winged males, and the process of the left hemitergite simple, there are seven Old World genera with this process simple, eight in which it is complex . . . a convergent feature . . . and also three neotropical genera. *Old World genera* (process simple): *Embia* Latreille; *Parembia* Davis, 1939c, Proc. Linn. Soc. N. S. W., 64: 478 (closely related to *Embia;* range Mesopotamia to India), and the Indian genera *Metembia* Davis, l. c., p. 474, and *Pseudembia* Davis, l. c., p. 476, derived from *Parembia*. *African genera* (process simple): *Dictyoploca* Krauss, 1911, Zoologica, 23: 54, (wingless); *Leptembia* Krauss, l. c., p. 71; *Dinembia* Davis, l. c., p. 559; and *Berlandembia* Davis, 1940, Proc. Linn. Soc. N. S. W., 65: —. *African genera* (process complex): *Donaconethis* Enderlein, 1909, Zool. Anz., 35: 176 (media usually forked); *Dihybocercus* Enderlein, 1912, Coll. Zool. Selys Longch., 3: 109; *Odontembia* Davis, 1939c, l. c., p. 489; *Enveja* Navás, 1916, Mem. R. Acad. cienc. y artes de Barcelona, 12: 13; *Rhagadochir* Enderlein, 1912, l. c., p. 54; *Macrembia* Davis, 1940, l. c., p. —; *Chirembia* Davis, 1940, l. c., p. —; *Parachirembia* Davis, 1940, l. c., p. —; *Navasiella* Davis, 1940, l. c., p. —. *Neotropical genera: Calamoclostes* Enderlein, 1909, l. c., p. 188 (R_5 lost in fore-wing; possibly not a constant feature) and *Pararhagadochir* Davis, 1940, l. c., p. —, with the process of the left hemitergite complex; and an unnamed genus with this process simple.

Family OLIGOTOMIDAE Enderlein

Oligotomidae Enderlein, 1909, Zool. Anz., 35: 190.

Genera: Oligotoma Westwood, 1837, Trans. Linn. Soc. Lond., Zool., 17: 373 (=*Aposthonia* Krauss, 1911, Zoologica 23: 48); *Haploembia* Verhoeff, 1904, Act. Acad. Leop.-Carol Halle, 82: 201.

Distribution: The natural range of *Oligotoma* seems to be the warmer parts of Asia, Australia, and the shores of the Indian Ocean (Seychelles, possibly East Africa; see Davis, 1939a, Proc. Linn. Soc. N. S. W., 64: 188). Recent species of *Haploembia* are restricted to the Mediterranean and Black Sea regions, but there is a doubtful species from the Oligocene of Prussia (see Davis, 1939c, Proc. Linn. Soc. N. S. W., 64: 464).

Structural features of the male terminalia unite these two genera in what seems to be a natural family. The tenth tergite is not as completely cleft as in the Embiidae, and the first segment of the left cercus is not echinulate . . . both features probably primitive. On the other hand, the wings are less primitive than in the Embiidae . . . they may be either lost entirely (*Haploembia* and forms of some species of *Oligotoma*), or, if present (most species of *Oligotoma*), they have R_{4+5} unbranched, and the strength of the veins generally reduced. This venational feature is, however, common to members of other families (*vide infra*).

Family **OLIGEMBIIDAE** new family

Genera: Oligembia Davis, 1939b, Proc. Linn. Soc. N. S. W., 64: 217 (type genus); *Diradius* Friederichs, 1934, Arch. Naturg., 3: 419.

Distribution: Paraguay, Brazil, Panama, Mexico, Florida, Antilles.

The prior genus *Diradius* is included in this family but passed over in the selection of the family root. Certain important features of its structure are unknown.

The terminalia of the adult males of this family have reached an evolutionary stage corresponding rather closely to the Oligotomidae . . . the cerci are smooth and two-segmented, and the longitudinal division of the tenth abdominal tergite less complete than in the Embiidae. The venation, although showing the same weakening in the veins as seen in *Oligotoma*, is more complete, R_5 remaining distinct.

Family **TERATEMBIIDAE** Krauss

Teratembiidae Krauss, 1911, Zoologica von Chun, 23: 33.

Genus: Teratembia Krauss, l. c., p. 33.

Distribution: Argentina.

This family, known from a single specimen, differs from all recent Embioptera in having the vein R_{2+3} forked. R_{4+5} is

simple. The male terminalia show some resemblance to the Oligembiidae, but the homologies of the component parts require further elucidation. If it should prove that the single specimen has individually aberrant venation (R_4 secondarily detached from stem and re-attached to R_{2+3}), there would be good reason for considering the Oligembiidae as a subfamily only (Oligembiinae) of the Teratembiidae.

Family **ANISEMBIIDAE** Ross

Anisembiidae Ross, 1940, Ann. Ent. Soc. Amer., 33: —.

Genera: Anisembia Krauss, 1911, l. c., p. 74 (North America and Antilles); *Saussurembia* Davis, 1940, Proc. Linn. Soc. N. S. W., 65: —, (Central America and Antilles); *Mesembia* Ross, 1940, Pan-Pac. Ent., 16: 12 (Antilles).

This series of genera has the vein R_{4+5} simple; in *Anisembia* the two segments of the left cercus, distinct in *Mesembia* and *Saussurembia*, have been fused together; this almost certainly represents an evolutionary step subsequent to the loss of R_5. In some species and forms of *Anisembia*, the males have become wingless.

The first segment of the left cercus of the male is smooth in *Saussurembia*, but echinulate in *Mesembia;* in *Anisembia*, the composite left cercus is echinulate, sometimes only very weakly so. The condition in *Saussurembia* may be primitive (e. g., following direct descent from a type resembling *Clothoda*), or a secondary retention of a larval feature (e. g., if the genus is descended from one of the Embiidae).

Family **NOTOLIGOTOMIDAE** new family[4]

Genera: Notoligotoma Davis, 1936, Proc. Linn. Soc. N. S. W., 61: 244 (type genus) (Australia generally); *Metoligotoma* Davis, ibid., p. 248 (Eastern Australia); *Embonycha* Navás, 1917, Insecta (Rennes), 73–84 (Indo-China); *Burmitembia* Cockerell, 1919, The Entomologist, 52: 676 (Burmese Amber, ?Miocene); and *Ptilocerembia* Friederichs, 1923, Capitata Zool., 2: 1 (Sumatra, Java).

The Notoligotomidae form an Indo-Malayan and Australian series in which the two segments of the left cercus are

[4]Genera prior to *Notoligotoma* (*Embonycha*, *Burmitembia*, *Ptilocerembia*) are passed over in the selection of the family root, certain important features of their morphology being unknown.

fused in the adult male; as a subsequent evolutionary step, the vein R_5, present in *Ptilocerembia* and *Embonycha*, is lost (*Burmitembia*, *Notoligotoma* pars), or the wings are lost (*Notoligotoma* pars, *Metoligotoma*).

Assuming the smooth condition of the left cercus of *Burmitembia* to be secondary, as suggested under *Saussurembia*, the family could be derived simply from a type such as *Parembia* (Family Embiidae, India, etc.), with which the *Notoligotomidae* agrees in the complete fission of the tenth abdominal tergite.

Notoligotoma agrees in its general structure with *Anisembia* (R_{4+5} simple, or wingless; left cercus one-segmented). Study of distribution suggests very strongly, however, that *Notoligotoma* is derived from a type such as *Ptilocerembia* (R_{4+5} forked, left cercus one-segmented), whereas *Anisembia* is derived from *Mesembia* (R_{4+5} simple, left cercus two-segmented). The two important steps seem to have been taken in opposite sequence on the two lines of descent; the end products in the two families, having taken both steps, are closely convergent.

KEY TO THE FAMILIES OF EMBIOPTERA (MALES)

1. Tertiary or Recent 2
   Permian ..... **Protembiidae**
2. Ventral structures of male terminalia markedly asymmetrical 3
   Ventral structures of male terminalia not markedly asymmetrical .. **Clothodidae**
3. Fission of tenth abdominal tergite of adult male incomplete; hemitergites of this segment not separated by a membranous area extending forward to ninth abdominal tergite 4
   Fission complete, hemitergites separated by membranous area reaching ninth abdominal tergite 6
4. New World genera with radial sector three-branched 5
   Genera not indigenous in the New World; radial sector two-branched or wingless ..... **Oligotomidae**
5. R_{2+3} bifid, R_{4+5} simple ..... **Teratembiidae**
   R_{2+3} simple, R_{4+5} bifid ..... **Oligembiidae**
6. Central and North American genera with R_{4+5} simple, or wingless, **Anisembiidae**
   Otherwise 7
7. Indo-Malayan or Australian genera with the left cercus one-segmented in the adult male ..... **Notoligotomidae**
   Indian, African, Mediterranean and Neotropical genera with the second segment of the left cercus distinct in the adult male ..... **Embiidae**

NOTES ON TABANIDAE (DIPT.) FROM PANAMA

II. THE GENUS DICHELACERA MACQUART AND RELATED GENERA[1]

G. B. Fairchild,

Junior Entomologist
Gorgas Memorial Laboratory
Panama, R. de P.

The horseflies considered in the present paper belong to a group whose greatest development seems to have taken place in the Neotropical region. They are characterized by the presence of a long dorsal spur or spine on the basal part of the third antennal segment, the absence of macrotrichiae upon the subepaulet, and the presence in the great majority of species of shiny chitinized plates in the labellae. The numerous genera which have been described are for the most part not well characterized, and the whole group is badly in need of revision.

The species occurring in Panama fall, according to the latest classification of Kröber (1934), into two subfamilies and five genera. I retain these genera in the present paper, not because I am satisfied that they represent the best possible grouping of the species, but because I feel that a paper dealing with a limited fauna is not the place for drastic generic revision. I believe, however, that the subfamily *Bellardiinae* is superfluous, and that all the present species belong in the old subfamily *Tabaninae*, which includes all species without hind tibial spurs.

KEY TO GENERA

1. Palpi markedly inflated, stout. Tibiae more or less inflated, and at least the hind pair with a fringe of long hairs. Antennae much shorter than frons, rather stout, the tooth long and blunt. Generally rather thick-set hairy species. . . . . **Stibasoma**

   Palpi slender to very slender. Tibiae slender, never long ciliate. Antennae may be longer than frons, the tooth slender and often pointed. Generally rather slender bare species. 2

2. Eyes densely pilose under a hand lens. Labellae pollinose, about one-third the length of the proboscis. Antennae with the tooth reaching the second annulus, rather blunt. . . . . **Dicladocera**

   Eyes bare. Labellae with at least some shiny areas. 3

[1]The present paper is the second in a proposed series on the Tabanidae of Panama. The first paper entitled "Notes on Tabanidae (Dipt.) from Panama. I. The Genera Chlorotabanus Lutz and Cryptotylus Lutz" is to appear in the December number of the Revista de Entomologia, Rio de Janeiro.

3. Labellae large, about half the length of proboscis, mostly pollinose, but with a small shiny plate near the base. (In the sole Panamanian species, the body is black, the wings black at base and with a broad black discal band), **Catachlorops**

Labellae small, hardly one-third the length of the proboscis, completely shiny and chitinized....4

4. Frons narrow, the callus not as wide as the frons. Thorax and abdomen without transverse markings. Species generally 15 mm. or larger...**Psalidia**

Frons moderate to broad, the callus as wide as the frons. Thorax and abdomen (in all our species) with prominent transverse markings. Species generally less than 12 mm....**Dichelacera**

Genus **Stibasoma** Schiner

1867, Verh. z. b. Ges. Wien., XVII, p. 310; Reise Novara, Zool. Theile, Dipt., pp. 93–94 (Type *Tabanus theotaenia* Wied.). Lutz, 1915, Mem. Inst. Osw. Cruz, VII, p. 100. Kröber, 1932, Stett. Ent. Zeit., XCIII, p. 241. Knab, 1913, Proc. U. S. Nat. Mus., XLVI, pp. 407–412.

Four species of the genus are thus far known from Panama, and all seem to be rather rare. I have taken but one of them personally. Dunn (1934) describes the flight of *chionostigma* as noisy and clumsy; the single specimen of *apicimacula* n. sp. buzzed loudly about my head.

KEY TO FEMALES OF **STIBASOMA**

1. Wings largely black....3

Wings largely hyaline or yellow....2

2. Wings entirely yellowish and grayish hyaline; sides of thorax rufous; abdomen with all tergites transversely banded....**fulvohirtum**

Wings yellowish with a black apical spot; sides of thorax black; abdomen with light transverse markings on first and second tergites only..**apicimacula**

3. Wings blackish with a yellowish hyaline patch behind the stigma and including the discal cell, and with the apex hyaline; abdomen all black above, the sternites with conspicuous yellow hind margins....**chionostigma**

Wings deep black, the apical and hind margins somewhat paler; abdomen pale yellow on first two segments, reddish and with rufous hair on succeeding ones....**theotaenia** var. **panamensis**

Stibasoma chionostigma (Osten-Sacken)

(Figs. 5, 5a, 5b)

1886, Biol. Centr. Amer., Dipt. I, p. 54, Pl. I, fig. 11, ♀ (Guatemala) (*Tabanus*). Williston, 1901, Op. Cit., Suppl. 1, p. 259. (Mexico) (*Tabanus*). Kertész, 1900, Cat. Tab., p. 45, (*Tabanus*). Knab, 1913, Proc. U. S. Nat. Mus. XLVI, No. 2033, p. 411 (=*pachycephalum* Big. 1892). Surcouf, 1921, Gen. Insect., p. 53. Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 387 (=*pachycephalum* Big.).

Stibasoma pachycephalum Bigot, 1892. Mem. Soc. Zool. France, V, p. 636 (Mexico). Kertész, loc. cit. p. 34. Ricardo, 1904, Ann. Mag. Nat. Hist., (7), XIV, p. 361. (Types 2 ♂, antennae defective). Knab, loc. cit., pp. 408, 411. Surcouf, loc. cit. p. 53. Enderlein, loc. cit. p. 387. Kröber, 1932, Stett. Ent. Zeit., XCIII, p. 251 (with *chionostigma* O. S. as syn.); 1934, Rev. Ent., IV, 2, p. 263.

Stibasoma flavistigma Hine, 1912, Ohio Nat., VII, No. 7, p. 516 (♀, Vera Cruz, Mexico). Knab, loc. cit., p. 409. Hine, 1917, Trans. Amer. Ent. Soc., XLIII, No. 3, p. 171 (Costa Rica). Surcouf, loc. cit., p. 53. Enderlein, loc. cit., p. 387. Kröber, 1932, loc. cit., p. 245; 1934, loc. cit., p. 262. Dunn, 1934, Psyche, XLI, No. 3, p. 171 (Chiriqui, Panamá).

A specimen before me collected by Dunn in Chiriqui was determined by Hine as *flavistigma*, and agrees perfectly with

Osten-Sacken's description and figure. Furthermore, Dr. Bequaert informs me that in Hine's MS. notes he found a statement to the effect that *flavistigma* Hine was the same as *chionostigma* O. S. I am unable to find any justification for the use of *pachycephalum* Big. by Knab and others. The species seems to be uncommon.

Distribution: Mexico, Guatemala, Costa Rica, Panama.

Panama records: 1 ♀ Camp Pital, Chiriqui Prov., R. P. July 11, 1928 (L. H. Dunn coll.), 1 ♀ Cano Saddle, Gatun, C. Z. July ,1923 (Greene Coll. U. S. N. M.).

Stibasoma fulvohirtum (Wied.)

(Figs. 4, 4a, 4b)

1828, Auss. Zweifl. Ins., I, p. 155 (♀, Brazil) (*Tabanus*). Walker, 1854, List. Dipt. Brit. Mus., V, p. 150 (*Dichelacera*). Schiner, 1868, Reise Novara, Zool., II, Abt. 1, Vol. B, Dipt., p. 94 (♀, Colombia). Osten Sacken, 1886, Biol. Centr. Amer., Dipt., I, p. 57 (Panamá). Kertész, 1900, Cat. Tab., p. 34. Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 137. Ricardo, 1904, Ann. Mag. Nat. Hist., (7), XIV, pp. 360–361. Knab. 1913, Proc. U. S. Nat. Mus., XLVI, pp. 408 and 411 (♀, Trinidad). Lutz, 1915, Mem. Inst. Osw. Cruz, VII, p. 108, Pl. XXI, fig. 23 (♀, Marajo, mouth of Amazon. Erroneously called *dives* Wlk. on plate). Surcouf, 1921, Gen. Insect., Taban., p. 53. Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 387. Kröber, 1932, Stett. Ent. Zeit., XCIII, p. 255, fig. 5; 1934, Rev. Ent., IV, 2, p. 263 (Colombia, Venezuela, Panamá, Trinidad, Brazil, Georgia (U. S. A.).

Tabanus compactus Walker, 1854, List. Dipt. Brit. Mus., V, p. 222 (♀ Ega, Amazon River, Brazil). Osten Sacken, loc. cit., p. 57 (=*fulvohirtum*. Types seen).

Fulvohirtum appears to be the commonest species of the genus in Panama, but seems to be limited to the Atlantic side of the Isthmus. The species is said to attack man readily, though I have not taken it personally.

Distribution: Northern Brazil, Trinidad, Venezuela, Colombia and Panama. Kröber's (1934) record of "Georgia" (U. S. A.) is certainly erroneous.

Panama records: 3 ♀, Ft. Randolph, C. Z. December 20, 1929 (L. H. Dunn coll.); February 11, 1930 (J. B. Shropshire coll.); January 23, 1929 (C. H. Curran coll.); 1 ♀ Barro Colorado Is., C. Z. (W. C. Allee coll.) 2 ♀ Barro Colorado Is., C. Z. Dec., 1928 (C. H. Curran).

Stibasoma theotaenia (Wiedemann)

1828, Auss. Zweifl. Ins., I, p. 136 (♀, Montevideo) (*Tabanus*). Walker, 1854, List. Dipt. Brit. Mus., V. Suppl. 1, p. 200 (*Tabanus*). Schiner 1868, Reise Novara, Zool., II, Abt. 1, Vol. B, Dipt., p. 94, Pl. II, fig. 6 (♀). Kertész, 1900, Cat. Tab., p. 34. Hunter, 1901, Trans. Amer. Ent. Soc. XXVII, p. 137. Ricardo, 1904, Ann. Mag. Nat. Hist., (7), XIV, pp. 360–361. Brèthes, 1907, An. Mus. Nac. Buenos Aires, XVI, p. 284. Knab, 1913, Proc. U. S. Nat. Mus., XLVI, pp. 408–409. Surcouf, 1921, Gen. Insect., Taban., p. 53. Kröber, 1934, Rev. Ent., IV, 2, p. 263.

Stibasoma thiotaeniata Williston, 1895, Kansas Univ. Quart. Journ. III, p. 194.

Stibasoma thiotaenia Lutz, 1907, Centralbl. Bakt. Parasitenk., Abt. 1, Orig., XLIV, p. 143 (♂, ♀); 1915, Mem. Inst. Osw. Cruz, VII, p. 103, Pl. XXI, fig. 20.

Lutz and Neiva, 1909, Mem. Inst. Osw. Cruz, I, 1, p. 32; 1914, loc. cit., VI, p. 73. Kröber, 1932, Stett. Ent. Zeit., XCIII, p. 253, fig. 4.

Stibasoma theotaenia panamensis Curran, 1934, Fam. Gen. N. A. Dipt., p. 153, fig. 23 (head; no description).

Dr. Bequaert has kindly furnished me with some notes on this species, which I have not seen personally. Typical *theotaenia* from southern Brazil, Uruguay, and Paraguay, has the third to terminal abdominal tergites wholly black haired, as figured by Lutz (loc. cit. 1915), while Schiner's Venezuelan material, and the single specimen form Panama, have these tergites reddish and russet haired. Until examination of more ample material can be made, it would seem best to regard this form as a variety of *theotaenia*, for which the name *panamensis* may be used. This name was apparently placed on Curran's specimen by Bequaert, and Curran later used it when the figure in his book was made, without knowing that the name had not been published.

Distribution: Typical form: southern Brazil, Uruguay, Paraguay, and Argentina. Var. *panamensis:* Venezuela and Panama.

Panama records: 1 ♀, Barro Colorado Is., C. Z., January 3, 1929 (Curran).

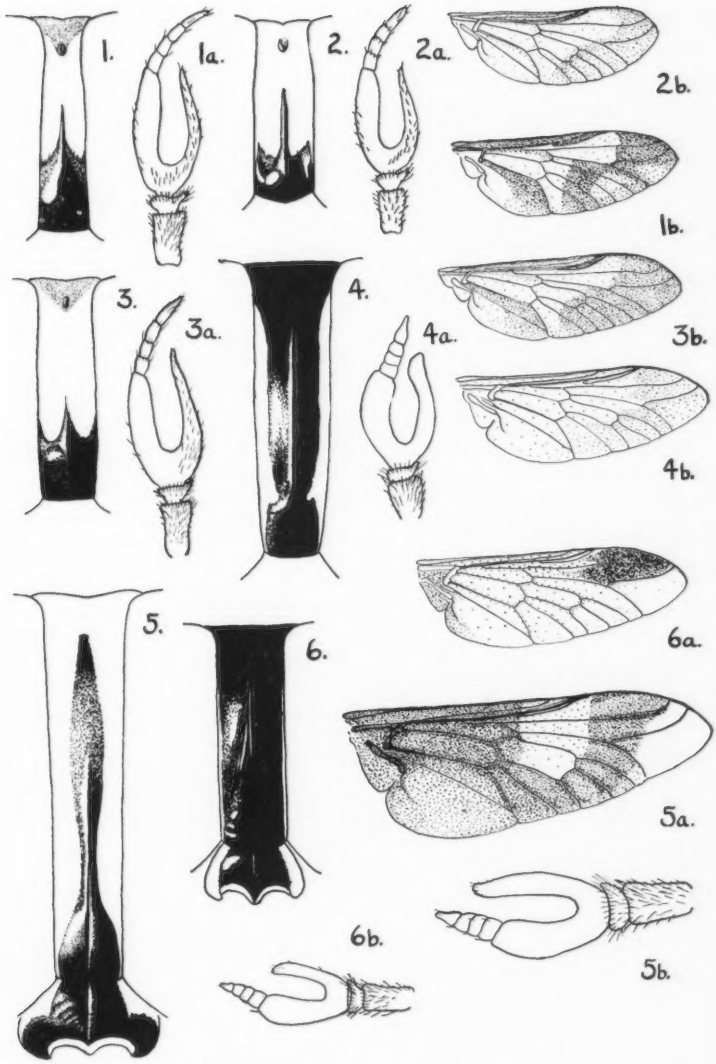
Stibasoma apicimacula n. sp.

(Figs. 6, 6a, 6b)

Female.—Length 13 mm., of wing 12 mm. Frons about 4 times as high as basal width, slightly narrowed below. The whole frons is shiny black, due to the enlargement and spreading of the calli, and only a thin line of gray tomentum remains along the eye-margin. Under proper illumination indications of a rounded basal callus and a spindle-shaped median callus may be seen. There is no vertexal tubercle.

Eyes bare, black with a slight greenish reflection in life. Subcallus denuded, black, shiny and with a deep median groove. Antennae black and black-haired on the first two segments, the third dark brown with golden pollinosity. The basal part of the third segment is more than twice as long as the annulate portion, and bears a long, stout, forward-pointing tooth which just reaches the first annulus. Annulations not well marked, the terminal longer than the others, sharply pointed. Palpi black, rather stout, sharply pointed, and shorter than the proboscis. Proboscis shorter than head height, black; the black shiny labella at least half as long as whole proboscis. Frontoclypeus and genae black, light gray pollinose, and with sparse black hairs.

Thorax and scutellum black, sparsely gray pollinose above. The prescutal lobe is conspicuously silvery pollinose. Pleura black, abundantly black-haired, except a tuft of silver white hairs just before the wing bases. Wings with the costal, basal, and bases of first and second submarginal cells orange yellow, and with a conspicuous brown spot



Figs. 1, 1a, 1b. *Dichelacera analis* Hine.
Figs. 2, 2a, 2b. *Dichelacera marginata* Macq.
Figs. 3, 3a, 3b. *Dichelacera regina* n. sp. Paratype.
Figs. 4, 4a, 4b. *Stibasoma fulvohirtum* (Wied.).
Figs. 5, 5a, 5b. *Stibasoma chionostigma* (O. S.).
Figs. 6, 6a, 6b. *Stibasoma apicimacula* n. sp. Holotype.

filling the apices of the first and second submarginal cells beyond the stigma. Rest of wing hyaline. Subepaulet without macrotrichia. All cells but anal open; no appendix on third vein.

Legs entirely black and black-haired, except that the bases of all tibiae bear sparse white hairs. The usual dense fringes of the tibiae are much reduced in this species, only a rather sparse row of long hairs on the hind tibiae being present. All tibiae somewhat swollen, the fore pair markedly so.

Abdomen black, for the most part shiny. The first tergite bears a median transverse patch of long pale yellow hairs on its hind margin, and the second tergite bears a complete transverse band of similar but shorter hairs on its hind margin. The remainder of the abdomen is wholly black. Beneath, all the sternites bear narrow yellowish hind-marginal bands.

Holotype ♀, El Valle, Coclé Province, Republic of Panama, 2,500 ft. elev., June 22, 1940. To be deposited in the Museum of Comparative Zoology, Cambridge, Mass.

This species is abundantly distinct from any *Stibasoma* known to me. The sparse pilosity and peculiar wing markings made me hesitant at first of its generic allocation, but there seems no structural difference which would warrant its separation. Its nearest relative in the Panama fauna seems to be *S. fulvohirtum* Wied.

Genus **Dicladocera** Lutz

1909, Instituto Oswaldo Cruz em Manguinhos, p. 29 (7 Neotropical species; no type designated); 1911, Inst. Hyg. Ausst., Dresden, p. 34; 1913, Brasil Medico, No. 45, pp. 4, 5 (in key, no species); 1914, Mem. Inst. Osw. Cruz, VI, 2, pp. 165, 166 (in key only); 1922, Zoologia Medica, Publ. Sep. da Folha Medica, pp. 8, 11. J. Bequaert, 1924, Psyche, XXXI, 1, p. 28 (Type *D. unicolor* Lutz 1912). Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 384 (Type *T. guttipennis* Wied. 1828). Kröber, 1931, Rev. Ent., I, 3, pp. 284, 286; 1932, Rev. Ent., II, 2, pp. 191, 199. Borgmeier, 1933, Rev. Ent., III, 3, p. 291. Kröber, Rev. Ent., 1934, IV, 2, p. 267. Stone, 1938, U. S. Dept. Agric., Misc. Pub.. No. 305, p. 14.

Of the seven species originally included by Lutz, all but *guttipennis* Wied. and *macula* Macq. have been placed elsewhere by Enderlein and Kröber, while the latter has added a considerable number of species, his catalogue (1934) listing 27 Neotropical forms. The genus was established by Lutz for species with dark unicolorous eyes, long antennal tooth, slender palpi, and slender abdomen. Enderlein (1925) and Kröber (1932) separate it from related genera on the long antennal tooth, hairy eyes, and stout build. Stone (1938), following Enderlein and Kröber, has included a number of North American species in the group on the basis of hairy eyes and a long antennal tooth. The relatively broad frons and inflated palpi of these North

American forms arouses the suspicion that they are not closely related to the Neotropical members of the group.

The single Panamanian species has the following characters: Frons rather narrow, callus more or less linear and ridge-like. Ocelli and vertexal tubercle absent; subcallus pollinose. Eyes densely pilose. Antennae shorter than frons, the tooth long and slender, blunt at tip, and reaching beyond the second annulus. Annulate portion unusually short, less than one third the length of the basal portion. Fronto-clypeus pollinose. Palpi very slender, fully as long as antennae. Proboscis at least as long as fore femora, the labellae about one-third the length of the proboscis and pollinose. Subepaulet without macrotrichiae, wing venation normal. General habitus normal, neither as slender as *Dichelacera* nor as stout as *Stibasoma*.

Dicladocera badia Kröber

(Figs. 7, 7a, 7b)

1931, Rev. Ent., I, 4, p. 402, fig. 2 (♀, Bocas del Toro, Panamá); 1934, Op. cit., IV, 2, p. 268.

Female.—Length 13 mm., of wing 13 mm. General color cinnamon brown. Legs yellowish brown. Pleura grey haired. Wings hyaline, with a broad pale brownish discal band, reaching from the stigma nearly to the hind margin. Abdomen with a large triangle of pale hairs on the fourth tergite.

Tabanus umbratus of Hine agrees very well with this species, except that the eyes are said to be bare.

Distribution: Known only from Panama.

Panama records: Bocas del Toro (Kröber). Porto Bello. March 3, 1911 (Busck).

Genus **Catachlorops** Lutz

1909, Inst. Osw. Cruz em Manguinhos, p. 29 (5 species, no type); 1911, Int. Hyg. Ausst., Dresden, p. 34; 1913, Brasil Medico, XXVII, No. 45, pp. 4, 6 (in key, no species); 1914, Mem. Inst. Osw. Cruz, VI, 3, pp. 165, 166 (reprinting of 1913 paper). Lutz and Neiva, 1914, Mem. Inst. Osw. Cruz, VI, 2, p. 21 (in list). Bequaert, 1924, Psyche, XXXI, 1, p. 27 (Type, *Dichelacera fuscipennis* Macq.). Enderlein, 1925, Mitt. Mus. Berlin, XI, 2, p. 404 (= *Dicladocera* Lutz). Kröber, 1931, Ann. Mus. Hung., XVIII, p. 340; 1932, Rev. Ent., II, 2, pp. 192, 200 (Subgenus of *Gymnochela* End.). Borgmeier, 1933, Rev. Ent., III, 3, p. 289. Kröber, 1934, Rev. Ent., IV, 2, p. 272.

Stictotabanus Lutz and Neiva, 1914, Mem. Inst. Osw. Cruz, VI, 2, p. 72 (with *St. maculipennis* Macq.). Bequaert, 1924, Psyche, XXXI, 1, p. 30 (Type *T. maculipennis* Macq.).

The original spelling was *Katachlorops* and Lutz used *Gatachlorops* also, but the above is the variant he used most often. Enderlein introduced *Catochlorops*. The group was

founded by Lutz for Tabanids with a long antennal tooth having the eyes bicolored. Kröber (1932) separates it from other Dichelacerate genera mainly on general habitus and tinctorial characters.

The genus is doubtfully distinct from *Dichelacera*, with which it is connected by such forms as *D. melanosoma* Hine. However, I retain the name for the time being for the single species found in the region under discussion.

Catachlorops transposita (Walker)

(Figs. 8, 8a, 8b)

1854. List Dipt. Brit. Mus., V, p. 151 (♀; Colombia) (*Dichelacera*). Kertèsz, 1900, Cat. Tab., p. 36. Ricardo, 1904, Ann. Mag. Nat. Hist., N. S. (7) XIV, p. 376. Surcouf, 1921, Gen. Insect., p. 93.

Catachlorops transposita Kröber, 1931, Ann. Mus. Hung., XVII, p. 341, (in key only); 1934 Rev. Ent., IV, 2, p. 273.

Female.—Length 13 mm., of wing 11.5 mm. Frons about five times as high as the basal width, callus black and shiny, practically as wide as frons and prolonged above nearly to vertex. Vertexal tubercle small and indistinct. Subcallus and face greyish pollinose. Eyes bare, unicolorous, blackish in life. Palpi black, very slender, slightly longer than antennae. Proboscis blackish, longer than palpi, the labellae about half the total length of proboscis, largely membranous and with but a small shiny plate near the apex.

Thorax black, grey pollinose, scutellum reddish, pleura greyish white. Legs black, except the basal halves of fore and, to a less extent, the mid tibiae, which are white. Wings with subepaulet bare, all cells but anal open and a mere stub of an appendix on the upper branch of the third vein. Wings hyaline, with the base, costal cell, and a broad discal band black. Abdomen black above, sparsely black-haired, and with a large, prominent white middorsal triangle on the fourth tergite. The extreme sides of the first to fourth segments are white haired, while all the sternites bear white hind margins.

The generally black color and the wing markings will easily separate the species from any in our fauna.

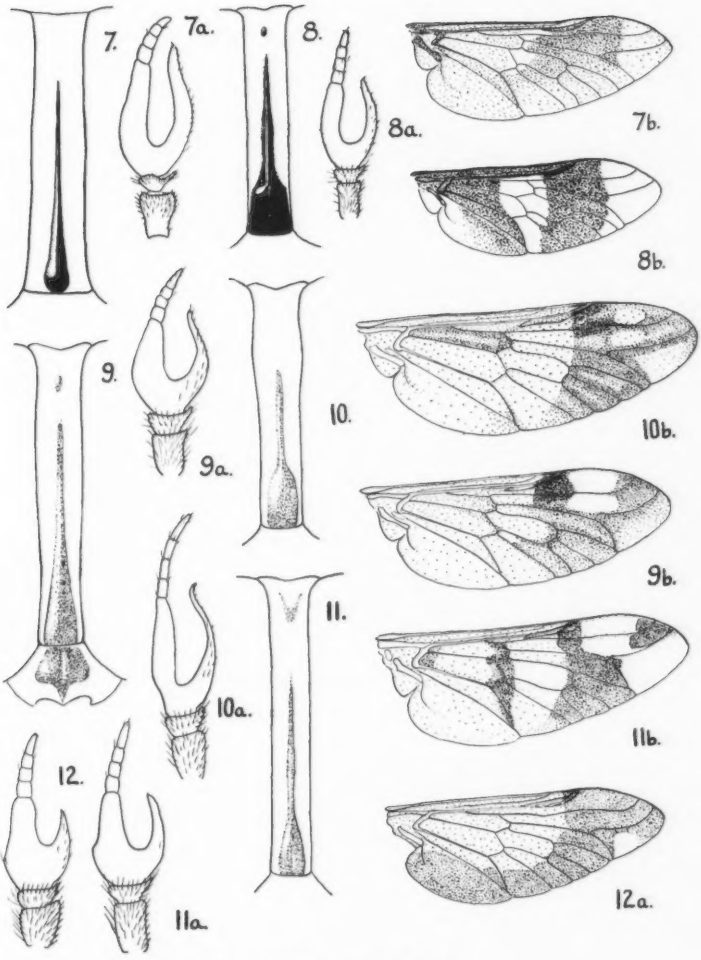
Distribution: Colombia and Panama.

Panama records: 2 ♀, Camp 3, upper Pequeni River, R. P., March 27, 1909. (A. H. Jennings; in U. S. N. M.) 1 ♀, Police Station, Pequeni River, R. P., April 10, 1940 (J. O. Barnes).

Genus **Psalidia** Enderlein

1922, Mitt. Mus. Berlin, X, 2, p. 344. (Type *Pangonia furcata* Wied. 1828); 1925, Op. cit., XI, 2, p. 393. Kröber, 1932, Rev. Ent., II, 2, p. 198; II, 3, p. 290. Borgmeier, 1933, Rev. Ent., III, 3, p. 299. Kröber, 1934, Rev. Ent., IV, 2, p. 260.

Enderlein erected this genus to include *Dichelacera*-like species with a closed first posterior cell, and included it in his subfamily *Bellardiinae*, a highly artificial group also based



Figs. 7, 7a, 7b. *Dicladocera badia* Kröb.
Figs. 8, 8a, 8b. *Catachlorops transposita* (Walk.).
Fig. 9, 9a, 9b. *Psalidia ocellata* End.
Figs. 10, 10a, 10b. *Psalidia bahiana* n. sp. Holotype.
Figs. 11, 11a, 11b. *Psalidia victoria* n. sp. Holoypte.
Figs. 12, 12a, ? *Psalidia victoria* (supposed ♂).

The figures of all frons and antennas were drawn on squared paper using an ocular micrometer disc ruled in squares and are all to the same scale. The wings were drawn from specimens mounted in balsam, using a projection apparatus, and are all on the same, but considerably smaller, scale. All figures except 12 and 12a are females.

almost entirely on this one character. Kröber (1934) includes four species in the genus, *festiva* Hine, *fulminea* Hine, *furcata* Wied. and *ocellata* End. Of these, *festiva* Hine is the same as *ocellata* End., though unfortunately Hine's name is preoccupied, and *fulminea* Hine is probably but an extreme variant of the same species. *Furcata* Wied. is quite a different appearing insect, though the structure of the antennae and frons is quite similar to *ocellata*. Lutz (1909) included *furcata* Wied. in his genus *Dicladocera*, but subsequent authors have restricted that name to species with hairy eyes.

The "Genera" *Amphichlorops* Lutz, *Catachlorops* Lutz, *Dicladocera* Lutz, *Chelommia* End. *Psalidia* End. and *Dichelacera* Macq., are all very close, all having a bare subepaulet and a long dorsal tooth or spine on the third antennal segment. Lutz' genera were based mainly on difference in eye coloration, while Enderlein and Kröber used the presence of a closed first posterior cell, the relative length of the antennal tooth, and bareness or hairiness of the eyes to separate the groups. These characters do not seem to correlate very well in this section of the family, and it is my opinion that most of these names will have to be dispensed with or retained only in a subgeneric sense. For the present, however, *Psalidia* forms a convenient heading under which to discuss a small group of similar appearing insects.

The species of this group are medium-sized (15 to 20 mm. long) tabanids with strongly marked wings. The frons is very narrow, from 5 to 7 times as high as wide, the frontal callus is elongate, ridge-like, and a good deal narrower than the frons. The eyes are bare, bright green or dark greenish black with or without a median stripe. The antennae bear a long slender tooth on the basal part of the third antennal segment which reaches at least to the first annulus. The palpi are quite slender, and the long proboscis bears shiny labellae. *Furcata* is black, with heavily black marked wings, but the other species are orange-yellow with a rather characteristic brown and yellow wing pattern. The first posterior cell is closed and petiolate in the females of *furcata*, *ocellata* and *victoria* n. sp., narrowly open in the males of *ocellata* and *victoria*, and but slightly narrowed towards the margin in *bahiana* n. sp.

Although but one species of the group occurs in Panama it seems advisable to take this opportunity to give a key to the known forms and to describe two new species which have recently turned up in Brazil and Mexico.

KEY TO FEMALES OF *PSALIDIA*

1. Body black. Wings heavily black marked.....**furcata** (Brasil)
   Body largely orange-yellow. Wings brown and yellow.....2
2. Antennae very slender, longer than frons. Orange discal area of wing strongly demarcated from distal brown area, its outer border smoothly curved. Discal cell entirely hyaline.....**bahiana** (Brasil)
   Antennae much shorter than frons. Outer border of yellow discal area irregular, discal cell infuscated at apex.....3
3. Wing yellowish hyaline, with a narrow dark band at the apices of the basal cells, another in the region of the stigma which broadens posteriorly to include the first to fourth posterior cells, and a third dark patch in the apex of the first submarginal cell. Subcallus pollinose.....**victoria** (Mexico)
   Wings largely smoky, yellowish in the proximal and discal areas, dark brown distally, and with more or less distinct hyaline spots in the discal, marginal, and first submarginal cells. Subcallus bare in the middle...**ocellata** (Panama)

Psalidia ocellata Enderlein

(Figs. 9, 9a, 9b)

1925, Mitt. Mus. Berlin, XI, 2, p. 393 (♀; Colombia, Bogota, Muzo). Kröber, 1931, Stett. Ent. Zeit., XCII, p. 91 (♂; Mexico, Chiapas); 1932, Rev. Ent., II, 3, pp. 292–293 (♀; Venezuela, Colombia, Panama, Costa Rica and Honduras); Rev. Ent., IV, 2, p. 261 (Mexico to Venezuela).

Tabanus festivus Hine, 1920, Ohio Journ. Sci., XX, 6, p. 187 (♀; Gatun, Canal Zone). Dunn, 1934, Psyche, XLI, 3, p. 174 (♀; Chiriqui, Panama). Not *T. festivus* Wied., 1828.

Psalidia festiva Kröber 1934 Rev. Ent., IV, 2, p. 260.

? *Tabanus fulmineus* Hine, 1920, Ohio Journ. Sci., XX, 6, p. 186 (♀; Gatun, Canal Zone).

? *Psalidia fulminea* Kröber, 1934, Rev. Ent., IV, 2, p. 260.

If, as seems highly probable, *fulminea* Hine should prove to be but an extreme variant of *ocellata* End., the former name must be used, as it has five years priority, but it seems better to await until Hine's types can be studied before making the change.

The wing pattern is quite variable, the oval hyaline spots in the marginal and submarginal cells sometimes being nearly obsolete, and the basal yellowish infuscation varying much in intensity. Kröber (1931) describes the male as having essentially the same wing pattern as the female, but with the first posterior cell open. The large facets of the eye occupy about two-thirds the eye area, but are not sharply marked off from the small facets. His specimen came from Chiapas, Mexico, the most northerly record for the species.

Distribution: Venezuela and Colombia to Southern Mexico.

Panama records: Gatun (D. E. Harrower) and Lion Hill (Busck), Canal Zone (Types); France Field, C. Z., June 25, 1929 (L. H. Dunn); Camp Pital, Chiriqui, R. P., July 13, 1929 (Dunn); Guabito, R. P., May (Kröber); Barro Colorado Is., C. Z., July 17, 1924 (Banks); Ancon, C. Z. (Dunn); El Valle, Coclé Prov., R. P., 2500 ft., May 20, 1939, July 9, 1939, June

16, 1940; Gatun, C. Z., August 4, 1923 (Dyar); Changuinola Dist., Bocas del Toro, R. P.; Moja Pollo, R. P., May 27, June 12, 1940. Rio Pequeni, R. P., August 20, 1940.

Psalidia bahiana n. sp.

(Figs. 10, 10a, 10b)

Female.—Length 17 mm., of wing 15 mm. Frons about six times as high as basal width, parallel sided, and clothed with orange yellow pollen. Vertex without any tubercle or shiny area. Antennae exceedingly slender, the tooth on the third segment thread-like and recurved at the tip. Face and subcallus yellow pollinose. Palpi thread-like, orange, about as long as antennae. Proboscis black, slender, longer than fore coxae; the labellae less than one third the total length of the proboscis, black and shiny. Eyes (relaxed) dull green, with a narrow median transverse dark stripe.

Thorax, abdomen, and legs, except the last tarsal joints, rufous orange. It is possible that in quite fresh material there may be a lighter broad middorsal abdominal band, but in my material this does not show.

Wings with subepaulet bare, the first posterior cell open but narrowed toward the margin, and the upper branch of the third vein with a very short spur or none. The costal and first basal cells are deep orange in color, the discal area below and including the basal half of the stigma, the discal and second basal cells, and the basal parts of the marginal, first submarginal, and first, fourth and fifth posterior cells, is clear yellow. The apical part of the wing is brown, more intense along the veins, and with an oval hyaline spot in the marginal and first submarginal cells, and a roughly triangular subhyaline area in the second submarginal cell. The inner margin of the wing is somewhat grayish.

Holotype ♀, Ilheus, Bahia, Brasil, October 11, 1934. To be deposited in the Museum of Comparative Zoology, Cambridge, Mass. There is also at least one other specimen in the M. C. Z. with the same data, but which is unfortunately not before me.

This species is quite similar in most respects to *Ps. ocellata* End., from which it differs mainly in the shape of the frons and antennae, the presence of a dark stripe on the eye, in details of the wing pattern, and the open first posterior cell. It may be said to represent *ocellata* in Southern South America.

Psalidia victoria n. sp.

(Figs. 11, 11a, 11b)

Female.—Length 18 mm., of wing 15 mm. Frons about seven times as high as the basal width, parallel sided, pale orange brown pollinose. Frontal callus yellow, slender, club-shaped, prolonged above two-thirds of the distance to the vertex, the latter with an oval yellowish denuded area. Antennae yellow, the tooth on the third segment barely reaching

the first annulus, and the basal part of the third segment with a distinct angle below. Subcallus and face pollinose. Palpi yellowish brown, slender, but not excessively so. Proboscis slender, the labellae black and shiny, the basal part yellow. Eyes bare, unicolorous, probably green in life.

Thorax, abdomen and legs pale yellowish red, the thorax somewhat grayish pubescent, the abdomen apparently darker, and immaculate, though it is somewhat crushed and rubbed.

Wings with subepaulet bare, the first posterior cell closed and petiolate, and the upper branch of the third vein without an appendage. The wings are hyaline, yellowish along the costa and below the stigma, and with the following brown markings. A patch occupying the apices of the basal and anal cells and base of the fifth posterior cell. Another larger patch occupies the apical halves of the first and fourth posterior cells, all of the second and third posterior cells, the extreme base of the second submarginal cell, the extreme apex of the discal cell, and extends to the costa as a narrow band between the stigma and fork of the third vein. There is, finally, a small patch in the apex of the marginal and first submarginal cells.

Holotype ♀, Compostela, Nyarit, Mexico (no date). To be deposited in the M. C. Z.

This species shows a wing pattern clearly derived from *ocellata* by a considerable reduction in the dark areas. I have also a male before me (Vic. Compostela, Nyarit, Mexico, June, 1934) which, in spite of its great differences in wing pattern, I thought might well be the male of *victoria*. However, Kröber's remarks on the male of *ocellata* have made me doubtful. I have, however, included a figure of the wing and antenna of this supposed male (figs. 12 and 12a). The eyes are bare, holoptic, and with the large and small facets not abruptly demarcated, and there is a small tubercle between the eyes at the vertex. The tarsi and apices of the tibiae are blackish, but otherwise the specimen agrees well in structure and habitus with *victoria*.

Genus **Dichelacera** Macquart

1838, Dipt. Exot., I, p. 112. Kertèsz, 1900, Cat. Tab., p. 35. Coquillett, 1910, Proc. U. S. Nat. Mus., XXXVII, p. 533 (Type, *D. unifasciata* Macq.). Lutz, 1915, Mem. Inst. Osw. Cruz, VII, 1, p. 71. Enderlein, 1922, Mitt. Zool. Mus. Berlin, X, 2, p. 346 (Type, *D. cervicornis* Fab.). Bequaert, 1924, Psyche, XXXI, 1, p. 38. Borgmeier, 1933, Rev. Ent., III, 3, p. 290. Kröber, 1934, Rev. Ent., IV, 2, p. 264.

Dichelocera Enderlein, 1925, Mitt. Zool. Mus. Berlin, XI, 2, p. 383 (Type *D. cervicornis* Fab.).

Rhamphis Enderlein, 1922, Mitt. Zool. Mus. Berlin, X, 2, p. 346; 1925, Op. cit. XI, 2, p. 391 (Type *Dichelacera bifascies* Walk.). Kröber, 1931, Rev. Ent., I, 3, p. 387 (subgenus of *Dichelacera*).

Neorhamphis Kröber, 1931, Rev. Ent., I, 3, p. 415; 1932, Op. cit., II, 2, p. 199 (Type, *T. varius* Wied.).

This genus as here understood contains rather small and slender flies, with mottled wings and generally with rather contrastingly marked bodies. The eyes are bare in all the Panamanian species, green with a single dark transverse stripe, or dark with two green stripes in life. In the male, the eyes are holoptic, the large facets occupying less than half the total eye area, and but little larger than the small facets, with no sharp line of demarcation between the two types. There is a small vertexal tubercle between the eyes. The frons of the female is medium to broad, generally with a well marked frontal callus, and, in our species, with a vertexal tubercle. The antennae are very long, generally longer than the frons, and bear a long forward pointing spine on the dorsum of the third segment which generally reaches at least to the first annulus. The palpi are slender, and the proboscis bears shiny labellae. The subepaulet is bare and the venation normal.

Four species of the genus have been recorded from Panama in the literature, but two of these, *D. cervicornis* F. and *D. submarginata* Lutz were apparently based on misidentifications. A third, apparently new, species is added in the present paper. All our species are primarily inhabitants of heavy forest, where they are on the wing throughout the day, and attack man very readily.

KEY TO FEMALES OF *DICHELACERA*

1. Distal dark fascia of wing of two more or less distinct dark patches; its proximal border step-like; second abdominal tergite without a posterior border of light hairs; prescutellar light area very narrow; mesonotum with a pair of brown patches anteriorly..... **analis**
   Distal dark fascia of wing uniform, its proximal margin rather regular; prescutellar light area at least half as wide as preceding dark band.....2
2. Wing markings quite indistinct; all abdominal tergites broadly margined with yellow hairs; prescutellar yellow band as broad as the interalar dark band preceding it..... **marginata**
   Wing markings prominent; first to fourth abdominal tergites margined with yellow, rest black; prescutellar yellow band about half as wide as preceding dark band..... **regina**

Dichelacera analis Hine

(Figs. 1, 1a, 1b)

1920, Ohio Journ. Sci., XX, 8, pp. 316–317, fig. 2 (♂ ♀; Costa Rica, Panama); 1925, Occ. Pap. Mus. Comp. Zool., Univ. Michigan, No. 162, p. 35 (Key). Dunn, 1934, Psyche, XLI, 3, pp. 172–173. Kröber, Rev. Ent., IV, 2, p. 263. Curran, 1934, North Amer. Dipt., p. 152, figs. 14 (wing) and 24 (head).

? *Dichelacera cervicornis* Osten Sacken (nec. Fab.) 1886, Biol. Cent. Amer., Dipt., I, p. 58 (Chiriqui, Panama). Ricardo, 1904, Ann. Mag. Nat. Hist., (7) XIV, pp. 366, 369 (♂ ♀).

? *Dichelacera costaricensis* Kröber, 1931, Rev. Ent., I, p. 411, fig. 12 (♀; San Mateo, Costa Rica; Colombia).

The species is darker than either *marginata* or *regina*, and varies from 10 to 12 mm. in length. The eyes in life are blackish, with two narrow green transverse stripes. The thorax is yellowish brown on the anterior half, with two indistinct brownish shoulder patches. The transverse interalar band is very broad and black, and separated from the black scutellum by a narrow yellowish stripe. The legs are yellowish, but with the apices of fore and hind femora and all the tibiae extensively dusky. The wing has the discal dark band broken into two patches, while the hyaline areas are only faintly yellowish.

D. analis is very closely related to *D. cervicornis* Fab., and it is possible that it may eventually be relegated to the status of a northern race of that species. It differs from *cervicornis* chiefly in being darker. The interalar band in *cervicornis* is narrower, it lacks the brown shoulder spots, and the abdomen is lighter and with light transverse bands on segments 1 to 4. *Analis* lacks the light band on the second segment, though occasional specimens show a small median patch of light hairs.

Osten Sacken's record should almost surely be this species, and Ricardo's reference was perhaps based on the same material. I can find no distinctions of value in the original description or figure to separate Kröber's *costaricensis* from *analis*, and in fact his species was described from almost the same locality as *analis*, San Mateo, Costa Rica.

D. analis is the most abundant species of the genus in most parts of Panama, and at times becomes a serious nuisance by its persistent attacks on man and beast, especially in forested areas during the rainy season. The bite is sharp and painful, but leaves little after-effect.

Distribution: Panama and Costa Rica.

Panama records: Camp Pital, Chiriqui, R. P., July 11 to 29, 1929. (L. H. Dunn). Alajuela, R. P., November 8, 1929, August 13, 1929 (Dunn). El Valle, Coclé Prov., R. P., June 18, 1939, July 9, 1939. Juan Diaz, R. P., October 15, 1939. Barro Colorado Is., C. Z., June, July, August, October, November (various collectors). Changuinola District, Bocas del Toro, R. P. Also numerous other records from various localities in the Canal Zone with dates from May to November.

Dichelacera marginata Macquart

(Figs. 2, 2a, 2b)

1847, Dipt. Exot., Suppl. II, p. 14 (♀; Cayenne). Walker, 1854, List. Dipt. Brit. Mus., V, Suppl. 1, p. 152. Kertész, 1900, Cat. Tab., p. 35; 1908, Cat. Dipt.,

III, p. 216. Hunter, 1901, Trans. Amer. Ent. Soc., XXVII, p. 137. Ricardo, 1904 Ann. Mag. Nat. Hist., (7) XIV, pp. 367–369 and 370. Lutz, 1907, Centralbl. Bakt· Parastitenk., Abt. 1, XLIV, p. 144; 1915, Mem. Inst. Osw. Cruz, VII, p. 86, Pl. XX, fig. 7 (♀; Pará); 1928, Est. Zool. Parasit. Venezolanas, p. 56, Pl. 9, fig. 5 (♀; Venezuela). Hine, 1917, Trans. Amer. Ent. Soc., XLIII, pp. 293 (Key), 294 (Misspelled *emarginata*); 1925, Occ. Papers Mus. Zool. Univ. Michigan, No. 162, p. 35 (Key). Surcouf, 1921, Gen. Insect., Taban., p. 92. Bequaert, 1926, Med. Rep. Harvard Exped. Amazons, p. 235 (♀; Northern Amazonas). Kröber, 1934, Rev. Ent., IV, 2, p. 266.

Dichelacera hinnulus Walker, 1850, The Zoologist, VIII, Appendix, p. CXXII (♀; Pará, Brasil); 1854, List. Dipt. Brit. Mus., V. Suppl. 1, p. 153.

Dichelacera submarginata Dunn (nec Lutz) 1934, Psyche, XLI, 3, p. 173 (Chiriqui, Panama).

This is the smallest species of the genus occurring in Panama, the females seldom exceeding 10 mm. in length. The face is entirely yellowish pollinose, the frons rather broad. The eyes in life are bright green, with a narrow purple transverse median stripe, and with purple reflections along the upper and lower borders. The thorax is yellow, with a transverse dark band between the wings. The abdomen is yellowish brown, lighter on the first segment, and with broad yellow haired transverse bands on the hind margins of all tergites. The wings are faintly yellowish, with the apex and distal area as far as the fifth posterior cell lightly brownish. The anal cell is also lightly infuscated. The legs are entirely yellow, except for the tarsi and the hind tibiae, which are brownish black.

The male is practically identical with the female in coloration, but the body hairs are much longer. The eyes are holoptic, bare, and with the large facets but little differentiated from the small in size, and with no sharp line of demarcation between the two types. The vertex bears a prominent tubercle between the eyes. The antennae are more slender than in the female, and the dorsal tooth is relatively shorter.

Macquart's description is, as usual, poor, but I follow Lutz and others in the application of the name. Specimens from South America seem to almost lack the transverse dark thoracic band, according to Lutz's figures. Material before me from the Canal Zone area has the band somewhat blurred, while Dunn's material from Chiriqui has a very black and prominent band. Some of the Chiriqui specimens also show indications of a bare facial callus.

The species is not so abundant as *analis*, but has similar habits, and seems to be on the wing only during the rainy season.

Distribution: Northern Brazil to Southern Mexico.

Panama records: Camp Pital, near Pto. Armuelles, Chiriqui Prov., Panama, July 19 to 29, 1929 (L. H. Dunn). Tabernilla,

C. Z. (A. Busck). Gatun, C. Z., June, 1923 (Close). Bohio, C. Z., May 11, 1909 (Jennings). Taboga Is., June 9, 1911 (Busck). Barro Colorado Is., C. Z., July 3, 1933 (Hood); July 30, 1924 (Banks); May 12, 1939 (Fairchild); Mt. Hope, C. Z., October 30, 1939 (♂). New San Juan, R. P., September, 1939. Rio Pequeni, May 16, 1940.

Dichelacera regina n. sp.

(Figs. 3, 3a, 3b)

Female.—Length 12–13 mm., of wing 11–12 mm. Frons about four and one half times as high as wide, parallel sided and clothed with golden yellow pollen. Frontal callus black, somewhat higher than wide and as wide as frons, with a short to medium slender prolongtaion above. Vertexal tubercle present, and vertex clothed with black pubescence. Subcallus, fronto-clypeus and genae clothed with whitish yellow pollen, without bare callosities. Antenna long, about two-thirds length of fore femur. First and second segments brown, clothed with black hair, third segment reddish basally, black at apex. Antennal tooth long and slender, reaching well beyond the first annulus. Annulate portion more than half the length of the basal portion. Palpi orange yellow, yellow haired, slender, and nearly as long as the proboscis. Proboscis slender, about as long as fore tarsi, the labella large, black, and shiny. Eyes bare, in life dull green with a narrow median transverse purplish band, and the upper and lower margins somewhat empurpled.

Mesonotum and pleura golden yellow, the former crossed by a velvety black band between the wing bases. The yellow area between this band and the black scutellum is about half the width of the band.

Fore coxae and femora whitish yellow, the femora brownish at apex. Tibia whitish yellow, brown at apex. Tarsi black. Mid coxae, femora, and tibiae entirely yellow, tarsi black. Hind coxae and femora, except the brown apices, yellow, tibiae and tarsi entirely black.

Wings yellow and blackish brown. Costal cell, anal cell and anal area, and a wide uninterrupted distal band dark. The distal dark area begins just beyond the stigma, and includes the major parts of all the submarginal and posterior cells, fading out to leave a narrow spur of yellow just anterior to the fifth vein (Cu_1+1A). The proximal margin of the dark area passes through the fork of the third vein and the apex of the discal cell. The areas not included in the above are intensely yellow hyaline.

The first abdominal tergite is whitish yellow, entirely yellow haired; the second is also yellow, but densely black haired, except the hind border, which is yellow haired. The third and fourth tergites are black and black haired, with yellow and yellow haired hind margins, while the remaining tergites are wholly black. Beneath the abdomen is clear yellow.

Holotype ♀, El Valle, Coclé Province, Panama, 2,500 ft., June 22, 1940. 1 ♀ paratype, same data, but a teneral specimen. 1 ♀ paratype, El Valle, June 16, 1940. In addition, I have one

specimen from the same locality, taken in May, 1939, but of which only the wings remain after a visitation of ants. Holotype to be deposited in the Museum of Comparative Zoology, Cambridge, Mass.

This species seems most closely related to *D. cervicornis* F., *D. submarginata* Lutz, and *grandis* Ric. From the two former, it may be separated by the entire and uniform distal dark fascia of the wing, and from the latter by the absence of a dark facial callosity. The characters in the key should serve to separate it from the other Panamanian species. Like other species of the genus, it will readily attack man.

For the sake of completeness, mention should be made of *Tabanus venenatus* Osten Sacken. This species was described (1886, Biol. Cent. Amer., Dipt., I, p. 54) from Guatemala and the Volcan de Chiriqui, Panama, but I have never seen it. It is stated to be a greenish insect with smoky wings and a long, blunt tooth on the third antennal segment. Kröber (1932, Rev. Ent., II, p. 92, fig. 32) places it in the genus *Amphichlorops* Lutz. He also describes the male, and mentions having seen material from Costa Rica, Ecuador, Venezuela and Bolivia.

ORCHIDS OF MICHIGAN, by MARJORIE T. BINGHAM. Pages 1–87, 22 plates (5 in color), 6¼ x 9¼ inches, 1939. Published by the CRANBROOK INSTITUTE OF SCIENCE, (Bull. 15), Bloomfield Hills, Mich. Price, cloth bound, $1.50.

We quote the preface: "Orchids of Michigan is written for the lay naturalist who wishes to know more about these rare native plants. The descriptions of orchids while specific are not technical."

Our purchase of this lovely book was as a gesture to our helpmeet and chauffeur who always thrills when we run across another orchid in our wanderings in the Georgian Bay region of Ontario. We suspect the wifely thrill comes rather from the name and its social implications of tropical greenhouses, ermine wraps, glittering social functions, rather than from the innate beauty of the native orchids themselves. We have hesitated to psychoanalyze further than our suspicion.

The illustrations, except the six species illustrated by colored drawings, are remarkably good photographs of the various orchids undisturbed in their natural surroundings. The text, while in plain English, is fully as scientific as many plant descriptions in botanical Latin where terms are as elusively relative in meaning as are English descriptive terms. The present reviewer is overjoyed to find a worthwhile taxonomic work in attractive form and written in every-day English.

We recommend this lovely volume to every other husband whose wife trails him in the field. Say it with an orchid book.—C. H. K.

NOTES ON THE SIMULIIDAE OF PANAMA

(Dipt., Nematocera)

G. B. FAIRCHILD,
Junior Medical Entomologist,
Gorgas Memorial Laboratory,
Panamà, R. de P.

This paper is the result of attempts to identify Simuliidae collected from time to time during the past year in the Republic of Panama and the Panama Canal Zone. No claims as to its completeness can be made, as I have seen no material from the mountainous region of Chiriqui Province, and very little from Darien Province or the Atlantic coast of the Isthmus. Practically all the material, in fact, was taken in the Canal Zone or along the Pacific side of Panama west of the Canal Zone.

The literature records but two species of *Simulium* from Panama, while in the material before me I have been able to identify with fair certainty seven previously described forms, and three which appear to be new. In addition to these, I have seen material of two other species, but in one case the specimens are not sufficiently well preserved for description, and in the other, the single specimen was destroyed by ants before it could be studied. Furthermore, I insert here brief notes upon two other described species which are quite likely to occur within the boundaries of the Republic, but which I have not yet encountered.

Simulium sanguineum Knab (Bull. Ent. Res., VI, pp. 279–280. 1915–16), from the Rio Atrato, Colombia. This locality is near the eastern border of Panama. Knab mentions only the female, and gives no figures. It is described as a small black species with iridescent blue thoracic stripes and unarmed tarsal claws.

Simulium exiguum Roubaud (Bull. Mus. Hist. Nat., Paris. XII, No. 12, pp. 108–109). Described from Venezuela, and recorded by Bequaert from Guatemala (Onchocerciasis, pp. 212–214. 1934). It is said to be a small black species with yellowish legs, unarmed tarsal claws and bare stem vein. The male and early stages are unknown.

It is interesting to note that most of the described species reported herein have been recorded previously only from Central America north of Panama. *S. ochraceum* Wlk. has been recorded from South America, but I question the identification (see below under *ochraceum*). *S. metallicum* Bell. is recorded

from Trinidad, but as noted below under that species, there appear to be at least two forms going under this name. *S. mexicanum* Bell. apparently occurs in Venezuela, if my interpretation of *S. lugubra* Lutz and Tovar is correct.

From the point of view of possible public health significance, it might be well to point out that two of our species, *S. ochraceum* and *S. metallicum*, have been incriminated as vectors of *Onchocerca caecutiens* in Mexico and Guatemala. In North America, several species of *Simulium* are known to transmit *Leucocytozoön* infections of domestic birds.

For the purposes of the present paper, all the species are placed in the genus *Simulium*, as a discussion of generic and subgeneric problems would necessitate a far wider acquaintance with the group than I possess. The characters used in the keys are based entirely on external structures of the female and pupa, as I believe that where such characters exist, they are far more practical than those of the male genitalia. The pupal respiratory filaments, at least in the species I have studied, show admirable characters in their number and arrangement, and although there is some variation, there has never been any difficulty in separating the species on this basis. It is hoped, however, to discuss the male genitalia and larvae in a later paper.

All figures were drawn from material mounted in balsam, which, in the case of the legs, obscures the colors of the vestiture. The figures thus indicate only the color of the underlying chitin. The female genital fork is quite thin and tenuous in many cases, and is apt to become folded and twisted during dissection and mounting. Although there is considerable individual variation, this structure offers good specific characters if used with care.

KEY TO FEMALES

1. Basal section of radius (R_1) between the stem vein and insertion of R_{2+3} with at least a single row of macrotrichia 2
   Basal section of radius bare 6
2. At least the mesonotum rich golden yellow or orange in ground color 3
   Mesonotum blackish or brownish with various ornamentation 5
3. Tarsal claws entirely toothless. Mesonotum with a pair of dorsal and a pair of lateral silvery stripes. Abdomen yellowish with 3 or 5 rows of black tergal spots ..... **samboni** Jennings
   Tarsal claws toothed. Abdomen not spotted 4
4. Tarsal claws with a strong double basal tooth. Mesonotum yellow with 4 silvery stripes. Abdomen dusky, lighter basally. Legs mostly yellowish, **panamense** sp. nov.
   Mesonotum orange with 2 incomplete dorsal silvery stripes. Abdomen clear yellow on first three segments, black on remainder. Legs mostly blackish, **ochraceum** Wlk.

5. Large blackish species, over 2 mm. long. Tarsal claws with strong tooth. Legs largely blackish..... **mexicanum** Bell.
Small greyish species, less than 1.5 mm. long. Tarsal claws with very minute basal tooth. Legs largely yellowish..... **clarki** sp. nov.

6. Mesonotum with brilliant iridescent bluish-green scales, especially on sides. Frons shining black. Legs mostly dark, with some silvery pollinosity, **metallicum** Bell.
Mesonotum with or without silvery nacreous stripes, but without iridescent scales..... 7

7. Mesonotum with 4 prominent silvery or greyish stripes on a deep black ground, 8
Mesonotum without prominent stripes, grey or reddish brown..... 9

8. Stripes of mesonotum narrow, nacreous silvery, the lateral pair broken up into two short streaks or spots. Legs extensively blackish. Tarsal claws with a strong tooth..... **haematopotum** Mall.
Stripes of mesonotum broad, equal to or broader than the median black interval. Lateral stripes continuous. Legs, except tarsi, all yellowish. Tooth of tarsal claws very minute..... **marathrumi** sp. nov.

9. Mesonotum blackish, with indistinct greyish stripes, and long silvery hairs. Hind tibiae with a prominent dark ring on basal half. Small species, less than 2 mm. long..... **pulverulentum** Knab.
Mesonotum dull mahogany brown, thinly grey pollinose. Hind tibiae without dark ring. Large species, over 2.5 mm. long..... **virgatum** Coq.

KEY TO PUPAE

1. Respiratory filaments 6-branched..... 2
Respiratory filaments with 8 or more branches..... 3

2. The three main stems each fork close to and equidistant from the base. Cocoon lightly woven, a simple wall-pocket type without flaring sides, **metallicum**
Two of the main stems fork a short distance from the base, the third practically at the base. Cocoon of wall-pocket type, but with flaring sides.. **clarki**

3. Filaments 8-branched..... 4
Filaments with more than 8 branches..... 8

4. All forks rather close to the base..... 5
At least one fork quite far from base..... 6

5. Three main stems, bearing 4, 1, and 3 branches. Cocoon slipper-shaped, the margin produced into long finger-like projections..... **virgatum**
Four main stems, with 2, 3, 1, and 2 branches. Cocoon of wall-pocket type, with very wide flaring sides..... **ochraceum**

6. Three main stems, with 4, 2, and 2 branches, the terminal fork on the four-branched stem quite far from base. Cocoon as in *clarki*..... **haematopotum**
Two main stems..... 7

7. Main stems unusually stout, branches quite tapered. Main stems with 2 and 6 branches, the forks of the most basal branch of the 6-branched stem dividing it approximately into thirds. Cocoon a simple wall-pocket with irregular upper margin..... **marathrumi**
Main stems normal, branches slender throughout. Main stems branched as above, but basal branch of 6 branched stem with the forks close together, dividing the branch approximately in halves. Cocoon of wall-pocket type, but with flaring sides..... **samboni**

8. Filaments of 10 short stout branches. Cocoon slipper-shaped, the lower lip margin irregular..... **pulverulentum**
Filaments more than 10 branched..... 9

9. Filaments of 12 medium branches, all arising practically at the base. Cocoon slipper-shaped, the lower lip margin deeply dentate..... **mexicanum**
Filaments of 20 branches, arising from 3 main stems, one bearing 4 branches, the other two, 8 each. All forks fairly near base. Cocoon of simple wall-pocket type, the upper lip margin produced in the middle..... **panamense**

Simulium samboni Jennings

1915. Proc. Ent. Soc. Washington, XVII, p. 199–200 (♂ ♀; Empire, C. Z.). Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, p. 740.

Length of mesonotum and scutellum 1.0 mm., of wing 2.0 mm.[1]

Female.—Frons and clypeus with silvery pubescence and golden hairs. Antennae yellow. Front tarsi somewhat inflated. Legs without silvery scale-like hairs. Fore and mid femora and tibiae yellow, fore tarsi blackish, mid tarsi mostly yellowish. Hind legs as figured (Fig. 9). Thorax with mesonotum orange yellow, sparsely golden haired, and with four silvery stripes, a dorsal and a lateral pair. Pleura yellow with some dusky areas. Scutellum yellow, with long dark hairs. Abdomen poorly chitinized, yellow on first two tergites, 3rd to 6th tergites with small black median dorsal plates, and 1 or 2 series of dorsolateral dark spots. The terminal tergites are whitish and shiny. Laterally and beneath the abdomen is dusky and apparently without patches of silvery pubescence. Post-scutellum with some silvery pubescence. Tarsal claws simple, without tooth or strong basal heel (Fig. 8). Pupal filaments 8 (Fig. 31). Cocoon of wall-pocket type with widely flaring sides. Genital rod as figured (Fig. 24). Stem vein setose.

Male.—Similar to ♀, except that silver stripes of mesonotum reduced to short anterior patches, some silver pollinosity on fore tibiae, and large lateral patch of silver on 2nd tergite. Abdomen lighter, only the terminal segments dusky.

The adult is very similar to *S. panamense*, except that the abdomen is yellowish with longitudinal rows of rounded dark spots, and the midtarsal claws are entirely without teeth. The *pupa* is, however, very distinct, having 8-branched filaments about 1.6 mm. long.

Cocoon subconical, margin slightly thickened, irregular dorsally. No floor; texture thin. Length about 1.8 mm.

Panama records: Empire, C. Z. (♂ ♀ Types). Cerro Sta. Rita, Colon Prov., R. P. February 2, 1940. Rio Paloma, near Juan Diaz, Panama Prov., R. P. January 14, 1940. Quebrada Mañanita, near Pedregal, Panama Prov., R. P. January 14, 1940. El Valle, Coclè Prov., R. P. December 10, 17, 1939. Rio Puente, Panama Prov., R. P. April 27, 1940. Rio Callabaco, C. Z. Forest Reserve January 21, 1940. All bred from pupa on vegetation or detritus.

Of the three small yellow species of *Simulium* taken in Panama, the present one seems best to fit Jennings' description. It is the only species with the abdomen with conspicuous discrete dark spots. Jennings apparently did not preserve the

[1]The length of the whole insect is not given, as the abdomon is subject to much shrinkage.

pupae from which he bred his material, at least Dr. Alan Stone was unable to find them when he kindly undertook a comparison with my material, so that complete certainty in the identification is impossible at present. *Samboni* seems quite close to *callidum* D. & S., but differs in lacking the small black mesonotal spots, in the pupal filaments, which branch very much farther from the base, and in the cocoon, which has prominent lateral extensions on the substratum, said by Bequaert (1934, p. 212) to be lacking in *callidum*.

S. samboni is one of the most abundant species about the Canal Zone, the pupae being found on dead leaves and twigs in nearly every little stream I have examined, but it apparently does not attack man.

Simulium panamense n. sp.

Female.—Length of mesonotum and scutellum, 1.1 mm., of wing, 2.4 mm. Frons medium, much widened at vertex, grey pollinose with a few dark hairs. Antennae of 11 visible segments, yellow basally, darkening to brownish at apex, moderately pubescent. Palpi blackish, pubescent and moderately hairy. Proboscis yellowish brown.

Mesonotum (from above) rich orange yellow, rather translucent, with two parallel stripes of silver pollinosity reaching from the anterior margin, where they are widened slightly, to near the base of the scutellum. The stripes are narrow, less than half as wide as the median space between them. The mesonotum is covered rather evenly with mixed brassy and dark hairs. Viewed from the side, the pleuron and a stripe along the lateral margin of the mesonotum from its anterior angle to just above the wing base is silvery grey pollinose. Scutellum pale straw color, sparsely grey pollinose and with rather sparse erect brassy and dark hairs.

Legs: Fore coxae and femora yellow, tibiae yellowish white, dusky at apex, tarsi black, somewhat inflated. Mid legs entirely yellow, except extreme apices of tarsal segments, which are dusky. Hind coxae yellow, femora yellow, dusky at apex, tibiae black on apical third; apical half of 1st hind tarsal black (fig. 12). 2nd hind tarsal yellowish at base, black at apex, as are rest of tarsal joints. Calcipala well developed, pedisulcus broad and deep. Mid tarsal claws (fig. 20) with blunt double basal tooth.

Wings with stem vein setose, no branch on R_2. Halteres yellow. Abdomen poorly chitinized, dusky with a light spot on third tergite, pollinose, and with scattered hairs.

Pupa with twenty branchial filaments about 1.5 mm. long. All forks are quite close to the base (Fig. 39).

Cocoon 3.0 mm. long, subconic, the opening about 90 degrees to the long axis, but the cocoon is completely floored, the floor extending out in front a considerable distance. There is also a dorsal projection of irregular extent. The texture is moderately dense, but there are numer-

ous openings, particularly in the anterior part. The margins of the aperture may be slightly thickened.

This species seems nearest to *S. simplicicolor* Lutz, which also has 20-branched respiratory filaments, but it differs from that species in having a pair of silvery dorsal stripes on the mesonotum.

Holotype ♀, Allotype ♂, 4 ♀ Paratypes. El Valle, Coclè Prov., R. P. December 17, 1939. 5 ♀, 1 ♂ Paratypes. El Valle, March 17, 1940. 1 ♂ Paratype, Rio Puente, Panama Prov., R. P. April 21, 1940.

Simulium ochraceum Walker

1861. Trans. Ent. Soc. London, (N. S.) V, pt. 8, p. 332 (♀ Mexico). Kertèsz, 1902, Cat. Dipt., I, p. 289. Johannsen, 1903, New York State Mus., Bull, 68, p. 370 (♀). Aldrich, 1905, Cat. N. Amer. Dipt., p. 170. Bequaert, 1934, Onchocerciasis, pt. III, p. 210.

Odagmia ochracea Enderlein, 1925, Zool. Anz., LXII, p. 208.

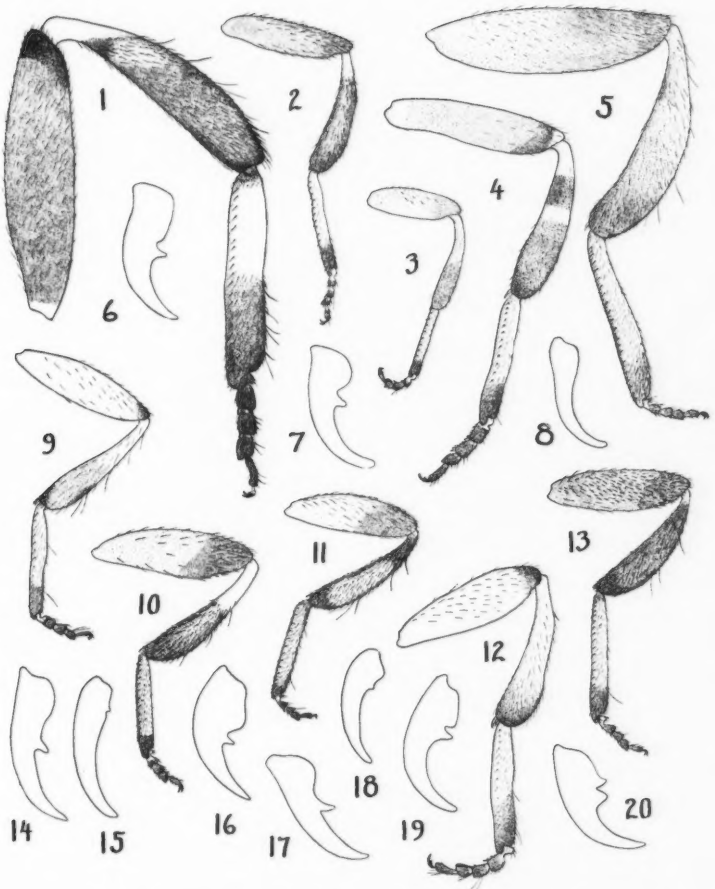
Eusimulium ochraceum Dyar and Shannon, 1927, Proc. U. S. Nat. Mus., LXIX, Art. 10, p. 16 (♀; Chiapas, Mexico). Dampf, 1931, Medecina, Revista Mexicana, XI., pp. 756, 757, 758, fig. 3, (♀ Chiapas) C. C. Hoffmann, 1930, Arch. Schiffs-u. Tropenhyg., XXXIV, p. 470; 1930, An. Inst. Biologia, Mexico, I, 4, p. 298, fig. 4 (♀); 1931, op. cit., II, 3, p. 217, figs. 3, 4, 5, 12, 14, 15 (larva and pupa).

Length of mesonotum and scutellum 0.71 mm., of wing 2.0 mm.

Female.—Frons pearly pollinose. Antennae reddish basally, the rest black. Legs without prominent silvery scales, the femora basally yellow, the tibiae and tarsi largely blackish (fig. 11). Front tarsi somewhat inflated. Mesonotum orange yellow, with two anterior dorso-lateral patches of silver pollinosity. Sides of mesonotum without silver. Pleura brownish with some silver pollinosity. Abdomen poorly chitinized, the first 3 segments clear yellow, the remaining black; tip of abdomen chitinized and shiny. Stem vein setose. Mid tarsal claws strongly toothed (fig. 6).

Male.—As in female, but no silver on mesonotum, and abdomen with pearly patches. *Pupa* with 8-branched filaments (fig. 35), *cocoon* of wall pocket type, the upper margin of the aperture somewhat thickened, the rear half floored over, and with widely flaring sides.

My material agrees well with Bequaert's and Hoffman's descriptions and figures, except that the pupal filaments branch somewhat more basally than shown in Hoffman's figure. *S. ochraceum* of Lutz and Tovàr [1928 Est. Zool. Parasit. Venezolanas, p. 45, Pl. 4, Fig. 4, (♀) Pl. 6, Fig. 3 (respiratory filament)], and of Pinto (1931, 7th Reun. Soc. Argentina Pat. Reg. Norte, pp. 739, 752, Fig. 10), seems to be different, as the arrangement of the pupal filaments is not the same, the size is larger, the abdomen entirely dark, and the legs extensively light colored. Recently, J. Lane and C. E. Porto (Bol. Biol. Sao



The figures of legs and genital forks are drawn to the same scale, the figures of the respiratory filaments are accompanied by a scale line, which in each case represents 0.5 mm., while the figures of the claws are not drawn to scale.

Fig. 1. Hind leg of *S. mexicanum*
Fig. 2. Hind leg of *S. haematopotum*
Fig. 3. Hind leg of *S. marathrumi*
Fig. 4. Hind leg of *S. pulverulentum*
Fig. 5. Hind leg of *S. virgatum*
Fig. 6. Mid tarsal claw of *S. ochraceum*
Fig. 7. Mid tarsal claw of *S. virgatum*
Fig. 8. Mid tarsal claw of *S. samboni*
Fig. 9. Hind leg of *S. samboni*
Fig. 10. Hind leg of *S. clarki*
Fig. 11. Hind leg of *S. ochraceum*
Fig. 12. Hind leg of *S. panamense*
Fig. 13. Hind leg of *S. metallicum*
Fig. 14. Mid tarsal claw of *S. mexicanum*
Fig. 15. Mid tarsal claw of *S. marathrumi*
Fig. 16. Mid tarsal claw of *S. haematopotum*
Fig. 17. Mid tarsal claw of *S. metallicum*
Fig. 18. Mid tarsal claw of *S. clarki*
Fig. 19. Mid tarsal claw of *S. pulverulentum*
Fig. 20. Mid tarsal claw of *S. panamense*

Paulo, (N. S.) IV, 2, p. 171, 1939) mention specimens (as *Eusimulium ochraceum*) from Bolivia, but they give no description.

The species has been bred from pupae on dead leaves in a small stream on the Atlantic side of the Isthmus, and a single pupa secured at El Valle on the Pacific side. It has not been seen to bite man.

Distribution: Mexico, Guatemala, Panama.

Panama records: El Valle, Coclè Prov., December 10, 1939 (pupa only). Cerro Sta. Rita, Colon Prov., February 2, 1940. Rio Puente, R. P. April 27, 1940.

Simulium mexicanum Bellardi

1862, Sagg. Ditt. Messicana, Appendice. p. 6 (♂; Tuxpango, near Orizaba, Mexico). Kertèsz, 1902, Cat. Dipt., I, p. 288. Johannsen, 1903, New York State Mus., Bull. 68, p. 369 (♂). Aldrich, 1905, Cat. N. Amer. Dipt., p. 170. Malloch, 1914, U. S. Dept., Agric., Bur. Ent., Techn. Ser., Bull. 26, p. 35 (♂ ♀). Bequaert, 1934, Onchocerciasis, pt. III, pp. 216–217, fig. 99 (♂ ♀, pupa, cocoon; Guatemala).

Odagmia mexicana Enderlein, 1925, Zool. Anz., LXII, p. 208.

usimulium mexicanum Dyar and Shannon, 1927, Proc. U. S. Nat. Mus., LXIX, Art. 10, p. 15; pl. IV, fig. 46 (♀; Cordoba, Mexico). Dampf, 1927, Rev. Mex. de Biologia, VII, p. 129. Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, p. 738.

Simulium aureopunctatum Malloch, 1914, l. c., p. 27 (♀; Guatemala). Pinto, 1931, l. c., p. 732.

Odagmia aureopunctata Enderlein, 1925, l. c., p. 208.

Eusimulium turgidum C. C. Hoffman, 1930, An. Inst. Biol., Mexico, I, 4, p. 298, figs. 6 and 13 (♀; Chiapas, Mexico). Pinto, 1931, l. c., p. 740.

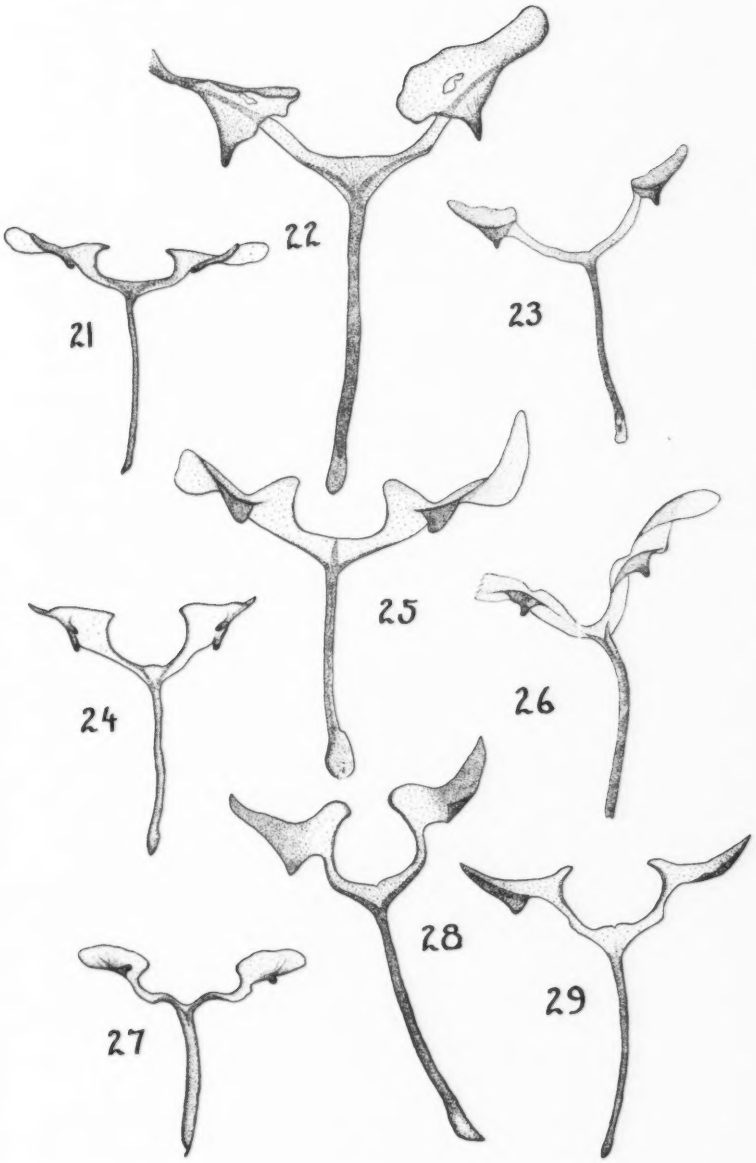
Simulium lugubre Lutz and Tovàr, 1928, Est. Zool., Parasit. Venezolanas, p. 46, pl. 4, fig. 2 (♀), pl. 6, fig. 6 (respiratory filaments of pupa; Venezuela). Pinto, 1931, l. c., p. 748, fig. 10 (respiratory filaments).

Female.—Length of mesonotum and scutellum, 2.0 mm., of wing, 3.5 mm. Frons about two and one-half times as high as wide, wider at vertex, grey pollinose with a row of black hairs along each eye margin and scattered hairs on vertex. Excision of eye border opposite antennal base broad and rather shallow. Clypeus about twice as long as broad, grey pollinose with sparse, long hairs. Antennae yellowish brown, 11-segmented, the third segment noticeably broader than the others, brownish pubescent. Palpi and proboscis blackish.

Mesonotum (from above) uniform dark grey pollinose with scattered golden or brassy hairs. Scutellum concolorous, with sparse long erect hairs along the margins. Pleura a little lighter than mesonotum.

EXPLANATION OF PLATE II

Fig. 21. Genital fork of *S. marathrumi*
Fig. 22. Genital fork of *S. mexicanum*
Fig. 23. Genital fork of *S. ochraceum*
Fig. 24. Genital fork of *S. samboni*
Fig. 25. Genital fork of *S. clarki*
Fig. 26. Genital fork of *S. metallicum*
Fig. 27. Genital fork of *S. haematopotum*
Fig. 28. Genital fork of *S. pulverulentum*
Fig. 29. Genital fork of *S. panamense*


22
21
23
25
24
26
28
27
29

Legs: Fore coxae and femora yellow with mixed yellow and black pubescence. Tibiae silvery pubescent on proximal two-thirds, black distally; tarsi all black, rather inflated. Mid coxae and femora dark, apex of latter yellowish; tibiae dark on apical half and on inside edge, proximal half yellowish and silvery haired on the outside; first tarsal white, black at apex, second basally white, others all brown to black. Hind legs as figured (fig. 1). Calcipala well developed, pedisulcus rather narrow. Mid tarsal claw toothed (fig. 14).

Wing with stem vein hairy; R_2 simple. Halteres yellow. Abdomen dark grey, the terminal segments well chitinized and shiny.

Cocoon slipper-shaped, the margins of the aperture lacelike. *Pupa* with 12 moderately short filaments, all of which arise close to the base (fig. 37).

My material agrees quite well with Bequaert's description. Lutz and Tovàr's descriptions and figures of the adult and the pupal filaments seem to fit the present species closely, though they do not mention the hairy base of the radius. In the text the length is given as 3–4 mm., which would be about right for this species, but the figure indicates a species considerably less than 2 mm. in length. However, the part of this work dealing with *Simuliidae* apparently was not checked, and the text and figures do not agree in many instances.

The species has been taken only at El Valle, R. P., at elevations above 2000 ft., and has not been seen to attack man.

Distribution: Mexico, Guatemala, Panama, Venezuela.

Panama records: El Valle, Coclè Prov., December 10, 1939, (in car); March 17, 1940 (bred from pupae on roots and dead leaves in a mountain stream).

Simulium clarki n. sp.

Female.—Length of mesonotum and scutellum, 0.9 mm., of wing, 1.9 mm. Frons subtriangular, narrow at antennae, broad at vertex, excision of eye margin opposite antennal base as deep or deeper than wide. Clypeus longer than broad, broadest at apex, narrow at antennal insertion. Frons and clypeus pale silvery grey pollinose, the former with a few, the latter with many silvery hairs. Antennae subcylindrical, of 11 segments, yellowish at base, darkening to a black apex, grey pollinose and pubescent. Palpi and proboscis dusky.

Mesonotum (viewed from above) uniformly silvery grey pollinose, rather evenly beset with well spaced silvery to pale brassy hairs, which are longer and denser on the margins than on the disc. On the posterior fourth and posterior lateral margin to as far forward as the level of the wing bases, these hairs point towards the anterior end of the insect, while those on the rest of the mesonotum point backward, and a ridge of upstanding hairs is formed where the two types join. Scutellum silvery grey with dense, long, curved, silvery hairs. Pleura and sides of mesonotum silvery grey pollinose.

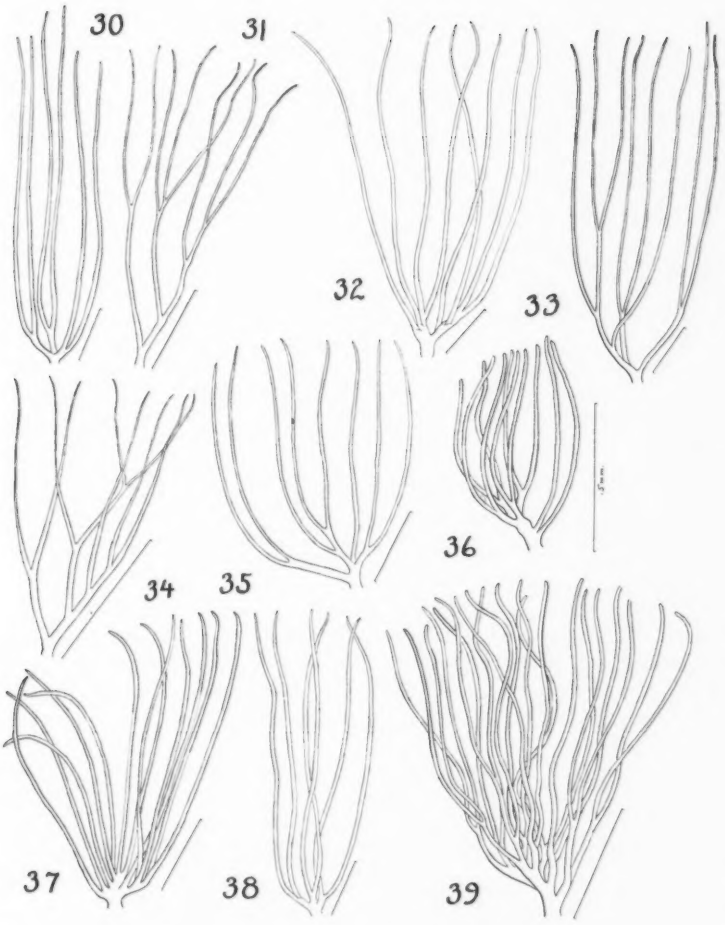


Fig. 30. Pupal respiratory filaments of *S. clarki*
Fig. 31. Pupal respiratory filaments of *S. samboni*
Fig. 32. Pupal respiratory filaments of *S. virgatum*
Fig. 33. Pupal respiratory filaments of *S. haematopotum*
Fig. 34. Pupal respiratory filaments of *S. marathrumi*
Fig. 35. Pupal respiratory filaments of *S. ochraceum*
Fig. 36. Pupal respiratory filaments of *S. pulverulentum*
Fig. 37. Pupal repiratory filaments of *S. mexicanum*
Fig. 38. Pupal repiratory filaments of *S. metallicum*
Fig. 39. Pupal respiratory filaments of *S. panamense*

Legs: Fore coxae and femora yellow with yellow pubescence, the latter very slightly dusky at apex. Tibiae yellow, with dense silvery pollinosity on the outer side and yellow pubescence on the inner; apex dusky. Tarsi black, slightly inflated, black pubescent. Mid coxae dusky, femora yellow, dusky at apex and with yellow pubescence. Basal third of tibiae white, silvery pubsecent, apical two thirds black, with mixed yellow and black pubescence. Basitarsis basally two-thirds white, rest and remaining tarsal segments black. Hind legs as figured (fig. 10). Calcipala and pedisulcus well developed. Claws of mid tarsi with a minute tooth (fig. 18).

Wings with stem vein hairy, R_2 simple. Halteres white.

Abdomen dusky with scattered pale hairs, the last five segments rather well chitinized, shiny.

Male.—Essentially like the female but mesonotum (from above) deep velvety black, more densely covered with rich golden hairs. With light of suitable incidence, a broad continuous marginal band of silvery pollinosity encircling the mesonotum can be made out. The scutellum is much less hairy, the abdomen, less highly chitinized, is velvety black, with patches of bright silvery pollinosity on the sides of tergites two and five.

Pupa with six-branched filaments 3.3 mm. long (fig. 30). *Cocoon* 2.8 mm. long, subconic. The aperture at about 90° to the long axis, the aperture sides flaring and produced beyond the aperture on the substratum. About half floored. Margin of aperture thickened. Texture quite loose and open, net-like laterally.

Holotype ♀, Allotype ♂, 1 ♀ 3 ♂ Paratypes bred from pupae on grass blades in a small stream feeding lily ponds at Summit Experiment Gardens, Summit, C. Z., January 9, 1940. 5 ♀ 4 ♂ Paratypes bred from water weeds in a small stream at El Valle, Coclé Prov., R. P. December 10, 1939.

Simulium metallicum Bellardi

1859, Sagg. Ditt. Mess., I, p. 14 (♂; Mexico). Kertèsz, 1902, Cat. Dpit., I, p. 288. Johannsen, 1903, New York State Mus., Bull. 68, p. 365 (♂). Aldrich, 1905, Cat. N. A. Dipt., p. 170. Roubaud, 1906, Bull. Mus. Hist. Nat. Paris, XII, p. 518 (♀). Malloch, 1914, U. S. Dept. Agric., Bur. Ent., Techn. Ser., Bull. 26, p. 48 (♀; larva, pupa) (? nec. Bell.) Dyar and Shannon, 1927, Proc. U. S. Nat. Mus., LXIX, Art. 10, p. 41, pl. V, figs. 72a, 73. (♀; Guatemala). Dampf, 1931, Medecina, Revista Mexicana, XI, pp. 754, 759, fig. 1 (♀; Chiapas, Mexico). Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, pp. 676, 731, 732, 735, 746.

Odagmia metallica Enderlein, 1925, Zool. Anz., LXII, p. 208.

Simulium avidum C. C. Hoffman, 1930, An. Inst. Biol., Mexico, I, 1, p. 52, figs. 1–4 (♀; Chiapas, Mexico); 1930, Op. cit., I, 4, p. 295, figs. 1, 7, 8 (♂ ♀); 1931, Arch. Schiffs-u. Tropenhyg., XXXIV, p. 470; 1931, An. Inst. Biol., Mexico, II, 3, p. 212, figs. 2a, 10, 13, 17 (larva and pupa). Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, p. 734.

Female.—Length of mesonotum and scutellum, 0.8 mm., of wing, 1.8 mm. Frons moderately broad, only slightly widened at vertex, shiny dark grey to blackish. Clypeus hardly twice as long as broad, covered

with flat, shiny nacreous scales. Excision of eye border opposite antennae broad and rounded. Antennae of 11 visible segments, cylindrical, pubescent, yellow at base, dusky greyish toward apex. Palpi and proboscis dusky.

Mesonotum (from above) black with four large grey patches. The two median grey patches are in the form of stripes, reaching from near the anterior margin to about three-fourths of the distance to the scutellum, narrow anteriorly, broadening into drop-shaped marks posteriorly. They are separated from each other by a narrower median black line, and from the large oval sublateral grey patches by somewhat wider black stripes. Under light of proper incidence, the dark areas are brilliantly pearly iridiscent. There are scattered black hairs, especially around the margins of the mesonotum. Scutellum black with grey pollinosity and black hairs. Pleura with pearly grey pollinosity, sides of mesonotum brilliantly bluish-green iridescent.

Legs: Fore coxae black on basal half, yellow apically, rather densely yellow haired, femora yellow, dusky at apex, and with silvery scales and whitish hairs. Tibiae dirty yellowish, with dense yellowish pubescence and silvery pollinosity, nearly black at apex, and with black hairs. Tarsi black and black haired, somewhat inflated. Mid legs with coxae dark, femora dark, both with some silvery pollinosity and rather dense, dark hairs. Tibiae dusky, yellow at base, pollinose and pubescent. First tarsal joint white with silver pubescence and pollinosity, dusky and dark haired at apex. Other tarsals yellowish with dusky hairs. Hind legs as figured (fig. 13). Calcipala and pedisculus normally developed. Tarsal claws toothed (fig. 17).

Wings with stem vein bare, R_2 simple. Halteres yellow.

Abdomen with a pearly patch on dorsum of first segment and sides of second segment. 3rd to 5th segments velvety black pollinose, terminal segments more heavily chitinized, shiny, dark brown.

Male.—Differs from female mainly in color. Mesonotum (from above) deep velvety black with two small anterior triangles and a patch anterior to the scutellum pearly iridescent. The pleural, lateral mesonotal, and abdominal pollinosity is more brilliantly iridescent than in the female. The mesonotal hairs are sparser and shorter while those on the scutellum are very long.

Pupa with six-branched respiratory filaments, the filaments long and the branches close to the base (fig. 38). *Cocoon* conical, of rather open weave, and with flaring sides.

I follow Bequaert (1934, p. 208) in the application of this name. *S. metallicum* of Malloch (1914), p. 28) at least in part, and of Pinto (1931, p. 676) seems to be a different species, as the pupa is said to have eight-branched respiratory filaments.

Distribution: Mexico, Guatemala, Costa Rica, Panama.

Panama records: El Valle, Coclè Prov., R. P. December 10, 1939 (bred from pupae on water weeds in mountain stream).

Simulium haematopotum Malloch

1914, U. S. Dept. Agric., Bur. Ent., Techn. Ser. No. 26, p. 62 (♀; Vera Cruz, Mexico). Dyar and Shannon, 1927, Proc. U. S. Nat. Mus., LXIX, Art. 10, p. 38, figs. 86, 87. (Mexico, Guatemala, Cuba, Puerto Rico). Dampf, 1927, Rev. Mex. de Biologia, VII, p. 129. Pinto, 1931, 7th Reun. Soc. Argentina Pat. Reg. Norte, p. 734. Bradt, S., 1932 Puerto Rico Journ. Public Health Trop. Med., VIII, 1, p. 77.

Female.—Length of mesonotum and scutellum, 0.8 mm., of wing 1.7 mm. Frons about twice as high as wide, silvery nacreous pollinose, the excisions of the eye border opposite the antennal bases broad and rather shallow. Clypeus longer than broad, concolorous with frons, and with sparse long hairs. Antennae 11 segmented, yellow, silvery pubescent. Palpi and proboscis brownish.

Mesonotum (from above) velvety black with a pair of rather narrow brilliantly nacreous dorsolateral stripes, broadest at the anterior margin and reaching posteriorly to the level of the wing insertions. The whole mesonotum is beset with golden hairs, sparse on the disc, more numerous around the edges. Scutellum brown, with a very few black erect hairs. Pleura brownish, silvery pollinose. The side of the mesonotum is velvety black, with a narrow arched nacreous streak extending from the posterior pronotum to just anterior to the wing base. Below this on the most ventral part of the mesonotum is an oval nacreous patch. With suitable illumination, a large nacreous patch may be seen upon the posterior aspect of the mesonotum anterior to the scutellum.

Legs: Fore legs all dark brown, except femora-tibial, and tibio-tarsal joints, which are narrowly yellowish. Fore coxae silvery pollinose, rest of legs dark pubescent. Mid coxae and femora black. Extreme base of tibiae yellowish, tarsi all yellowish white, the apices of the segments somewhat dusky. Hind legs (fig. 2) same as mid pair, the tarsi a little more extensively darkened. Calcipala and pedisulcus present. Tarsal claws (fig. 16) with strong sub-basal tooth.

Wing with stem vein bare, R_2 simple. Halteres yellow.

Abdomen velvety black with silvery pollinose lateral patches on the anterior segments, the terminal three segments brownish, shiny and well chitinized.

Male.—Differs in having the dorsal mesonotal stripes reduced to two anterior patches, the lateral mesonotal markings in the form of three rounded spots arranged in a triangle, and the abdomen being less chitinized posteriorly.

Pupa with 8 long branchial filaments (fig. 33). *Cocoon* about 2 mm. long, subconical, loosely woven with spaces, the aperture with a slightly projecting roof and flaring sides; margin not thickened, slightly irregular. Floor on posterior half only.

My material does not agree in certain respects with Dyar and Shannon's figures of this species (I was unable to consult Malloch's original description), as a comparison of our figures of the ♀ genital fork will show. *S. pseudohaematopotum* of C. C. Hoffman seems close also, but the genital fork is still different

and the tarsal claws are unarmed. *S. quadrivittatum* of Loew seems to be the name under which Dunn (1934, Psyche, XLI, 3, pp. 177–178) listed the present species, but no description of Loew's species is available to me here. It was described from Cuba, where *haematopotum* is stated to occur also. Bradt (l. c.) lists both species from Puerto Rico, but gives no description. It is probable that there are a number of similarly marked species in this group, but their elucidation will have to wait until further material accumulates.

This is the only species which seems to bite man at all readily at lower elevations on the Isthmus. During the latter part of the rainy season it becomes quite annoying at the Laboratory's station at Juan Mina on the Chagres River above Gamboa. The early stages have been taken on grass and dead leaves in a small stream which feeds the lily ponds at Summit Gardens, Canal Zone.

Distribution: Mexico, Guatemala, Cuba, Puerto Rico, Panama. I have recently received specimens from British Honduras which appear to be this species, though they are somewhat larger than my Panama material.

Panama records: Summit, C. Z., January 9, 1940. Juan Mina Station, Rio Chagres, C. Z., November 8, 1939. Canal Zone Forest Reserve October 11, 1939. Las Guacas, R. P., January 4, 1940. Guayabalito, R. P., October 20, 1938 (at light). Chilibre, R. P., November 23, 1939.

Simulium marathrumi n. sp.

Female.—Length of mesonotum and scutellum, 0.7 mm., length of wing, 1.5 mm. Frons broad, widened at vertex, eye border broadly excised around antennal base, greyish nacreous pollinose. Antennae of 10 visible segments, the first two apparently fused, broadest at the 3rd or 4th segment, dirty yellowish brown and quite hairy. Clypeus concolorous with frons. Palpi and proboscis dirty yellowish brown.

Mesonotum, (viewed from above and with the light from directly in front) deep velvety black with two very broad greyish nacreous dorsolateral bands reaching from the anterior margin to the scutellum, joining to form a transverse band before the scutellum. The median black interval is narrower than the bands, and there is a fine median light line upon it. The light bands are somewhat narrower posteriorly. The whole dorsum of the thorax is clothed with long, curved, brilliantly golden hairs. Viewed from the side, the pleura are greyish, and the sides of the mesonotum bear a greyish, nacreous band, reaching from the anterior angles of the mesonotum to above the wing bases. The scutellum appears to be greyish, densely covered with long, golden hairs. All legs clear yellow except front tarsi, apical half of hind tibiae, and

inner margin and apex of basitarsus (fig. 3). The last four tarsal segments of mid and hind legs are somewhat dusky. All legs have more or less of a vestiture of pale scale-like hairs. Fore tarsi cylindrical. Hind tarsus with well developed calcipala and pedisulcus. Mid tarsal claws with a very minute tooth (fig. 15). Wings with stem vein bare, R_2 not forked, halteres pale yellow.

Abdomen blackish, with a nacreous patch beneath the scutellum and probably on sides of some other segments, but so poorly is it chitinized, except for the apical segments, that little can be seen.

Male.—Differs from female in having the broad grey nacreous stripes of the mesonotum reduced to two triangular areas on the anterior fourth of the mesonotum. They are more iridescent than in the female, and are only visible when observed from the front. The golden hairs are more sparse, being absent from the disc of the mesonotum, and the scutellum is dark. The legs are as in the female except that the hind femora are more extensively dark.

Pupa with 8 branchial filaments (fig. 34). *Cocoon* roughly conical, the opening at 90° to the long axis, dorsally with a blunt angle. Closely woven, no spaces, and no marginal thickening.

This species bears certain resemblances to *S. paraguayense* Schrottky as interpreted by Lutz (1928) and Pinto (1931), but the smaller size, absence of a strong tooth on the tarsal claws, and the prominent grey mesonotal stripes should serve to distinguish it. The pupal filaments are somewhat like those of *S. lutzianus* Pinto 1931, a species described from a pupal shell from Venezuela, but the present species has shorter, more tapered filaments and the branching is somewhat different.

Holotype ♀, Allotype ♂, 2 ♀ 2 ♂ Paratypes, bred from pupae on *Marathrum schiedeanum* Cham., Rio Las Lajas, Panama Prov., R. P. November 20, 1939. 1 ♀ Paratype, Chorrera Falls, near Chorrera, R. P., March 31, 1940 (biting).

Simulium pulverulentum Knab.

1914, Ins. Ins. Mens., II, No. 12, pp. 177–178. (♀; Punta Gorda, British Honduras). Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, p. 734.

Female.—Length mesonotum and scutellum, 1.0 mm., of wing, 2.1 mm. Frons broad, broadest at vertex, greyish pollinose with scattered silvery hairs. Excavation of eye border opposite antennae quite deep. Clypeus concolorous with frons, rather hirsute. Antennae of 11 visible segments, reddish brown and quite hairy, the segments, except the narrower terminal, of about equal width, palpi and proboscis brownish, grey pubescent.

Mesonotum (from above) pale grey, with a narrow median and a pair of wider dorsolateral dark grey stripes, which do not reach the anterior border, and which widen and fuse on the posterior fourth of the mesonotum. Whole mesonotum with long, silvery hairs, sparse on the

disc, rather dense near the margins. Anterior lateral areas indistinctly mottled with dark grey. From the side, the mesonotum has a dark area between the shoulder and wing base, and the dorsolateral dark stripe appears to reach the anterior margin. Pleura grey. Scutellum grey, with dense silvery hairs pointing upwards and anteriorly.

Legs: Fore coxae yellow, femora dirty yellowish with dusky patches at base, middle and near apex; tibiae dirty yellowish, with a dark patch just beyond base and the apical third dusky; tarsi dark, slender. Mid coxae dusky, femora yellow, tibiae yellow at base, then a dark ring, then yellow again, and the apical half dusky; first tarsal segment with basal half yellow, the rest and the terminal tarsal segments dark. Hind coxae dark, basal third and extreme apices of femora yellow, rest dark; tibiae and tarsi same as mid legs (fig. 4). Basitarsis with a well developed calcipala, pedisulcus of second tarsal segment rather shallow. Mid tarsal claws with strong basal tooth (fig. 19).

Wings with stem vein bare. Halteres yellowish white.

Abdomen feebly chitinized, dark greyish pubescent, the terminal segments with scattered silvery hairs.

Male.—Essentially the same as female, but mesonotum with stripes obsolescent, either entirely black with a few grey patches anteriorly (viewed from above), or entirely grey with small black streaks anteriorly (viewed from the side). Shiny hairs much sparser than in female and brassy instead of silvery.

Pupa.—Branchial filaments 10, about ½ mm. long. All branches quite close together and to the base (fig. 36). *Cocoon* subconical, about 2 mm. long, slipper shaped, the aperture at about 60° to the long axis. Margin not thickened, but continuous all the way around opening. Close woven, no visible openings.

The only other described Neotropical species known to me with 10 respiratory filaments is *S. hirtipupa* Lutz, described from a single pupal skin from Minas Geraes, Brazil. *Pulverulentum* differs in having much longer filaments which are strongly annulated, and in lacking the numerous trichomes of *hirtipupa*. The immature stages of this species fairly swarm in some of the swifter and clearer streams of the Pacific slope, being partial to those with a heavy growth of *Marathrum schiedeanum* Cham., on whose finely divided leaves the pupae are often massed in incredible numbers. I have not observed this species biting.

Distribution: Hitherto only recorded from the type locality, Punta Gorda, British Honduras.

Panama records: Rio Las Lajas, Panama Prov., R. P., November 20, 1939. Chorrera Falls, Chorrera, R. P., March 31, 1940. Quebreda Mañanita, near Pedregal, Panama Prov., R. P., January 14, 1940. Rio Paloma, near Juan Diaz, Panama Prov., R. P., January 14, 1940.

Simulium virgatum Coquillett

1902, Proc. U. S. Nat. Mus., XXV, p. 97 (♂ ♀; Las Vegas, New Mexico). Johannsen, 1903, New York State Mus., Bull. 68, p. 383 (♂ ♀). Aldrich, 1905, Cat. N. A. Dipt., p. 170. Malloch, 1914, U. S. Dept. Agric., Bur. Ent., Techn. Ser., Bull. 26, p. 57 (♂ ♀; New Mexico, California). Dyar and Shannon, 1927, Proc. U. S. Nat. Mus., LXIX, Art. 10, p. 39, pl. VI, figs. 82–83, pl. VII, figs. 126–128 (♂ ♀). Pinto, 1931, 7th Reun. Soc. Arg. Pat. Reg. Norte, p. 737. Bequaert, 1934, Onchocerciasis, Part III, pp. 214–216 (♀, cocoon, pupa; Guatemala. Treated as var. *rubicundulum* of Knab.).

Odagmia virgata Enderlein, 1925, Zool. Anz. LXII, p. 208.

Simulium hippovorum Malloch, 1914, l. c., p. 28 (♀; Sierra Madre, Mexico).

Wilhelmia hippovora Enderlein, 1925, l. c., p. 207.

Simulium rubicundulum Knab., 1914, Ins. Ins. Mens., II, p. 178 (♀; Vera Cruz, Mexico; New Mexico).

Simulium virgatum chiapanense C. C. Hoffman, 1930, An. Inst. Biol., Mexico, I, 4, p. 295, figs. 2, 9. (♀ Chiapas, Mexico). Pinto, 1931, l. c., p. 737.

Female.—Length of thorax and scutellum, 2.0 mm., of wing 3.0 mm. Frons and clypeus grey pollinose. Antennae dusky. Mesonotum mahogany brown, with ill-defined stripes of thin grey pollinosity and sparse silvery hairs. All femora largely whitish, fore tarsi somewhat inflated. Tibiae black and white, the fore pair with some silvery hair. Mid and hind tarsi black and white (fig. 5). Abdomen blackish, the tergites fairly well chitinized, especially the terminal ones. Stem vein bare. Tarsal claws strongly toothed (fig. 7). Calcipala quite short, pedisulcus deep and wide.

Pupa with 8 rather long and stout filaments (fig. 32) branching close to the base. *Cocoon* slipper-shaped, with long finger like projections around the aperture. I have not taken the male.

My single bred ♀ agrees well with Bequaert's (1934) conception of the species, and the pupal filaments are like those figured for *S. chiapanense* by Hoffmann (1931).

Distribution: Mexico, Guatemala, Panama.

Panama records: Chorrera Falls, Chorrera, R. P., March 31, 1940 (bred from pupa).

REFERENCES

It seems unnecessary to give here an extended bibliography, as the papers by Jobbins-Pomeroy and Bequaert (1934) may be consulted for the older references. I have included a few of the more useful papers on taxonomy and those published subsequent to Bequaert's paper which were available to me.

1916. **Jobbins-Pomeroy, A. W.** Notes on five North American Buffalo gnats of the genus Simulium. U. S. Dept. of Agriculture, Bull. No. 329. Professional paper (contains 14 pages of references).

1927. **Dyar, H. G.,** and **Shannon, R. C.** The North American two-winged flies of the family Simuliidae. Proceedings U. S. National Museum, LXIX, Art. 10, pp. 1–54, Plates 1–7.

1931. **Pinto, C.** Simulidae da America Central e do Sul. Sèptima Reuniòn de la Sociedad Argentina de Patologia Regional del Norte, Tucuman. (Contains keys and illustrations of a number of species, and a complete list of the described Neotropical forms).

1934. **Strong, Sandground, J. Bequaert** and **Ochoa.** Onchocerciasis, with special reference to the Central American form of the disease. Contributions from the Department of Tropical Medicine and the Institute for Tropical Biology and Medicine, No. VI, Harvard University Press, Cambridge, Mass. (Part III, by Bequaert, refers to the Simuliidae, and contains an extensive bibliography).

1939. **Lane, John,** and **Porto, Carlos E.** Simulideos da regiao Neotropica. O Genero Eusimulium. Boletim Biologico, Sao Paulo, (N. S.) IV, 2, pp. 168–176, 7 text figures. (Contains key to genera, key to species, and discusses 8 species.)

1939. **Porto, Carlos E.** Simulideos da Regiao Neotropica (II-Genero Simulium) Boletim Biologico, Sao Paulo, (N. S.) IV, 3, pp. 369–373, 3 text figures. (Discusses 3 Brazilian species.)

1939. **Orfila, R. N.** Simuliidae (Dipt) de la Republica Argentina. 9th Reuniòn de la Sociedad Argentina de Patologia Regional, Mendoza, Oct., 1935, III, pp. 1525–1534. 1939. (Contains keys to subgenera and species, and lists 30 species with synonymies.)

NOTICE TO AUTHORS OF ARTICLES WHICH HAVE APPEARED IN THE ANNALS

The Annals store room furnished by the Ohio State University is too crowded for further storage of the forty or fifty cases of cuts which have been used in printing the illustrations in the Annals. These are the property of the various authors who have paid for them. The Annals staff has stored and indexed these cuts to the year and issue, hoping they could be loaned for later use in other publications. About one such request for a cut or two is received in the course of two to five or more years. It is proposed to destroy them where the author is not enough interested to request them returned and to pay expressage for their return. The cuts of vols. I–X will be destroyed this fall, or we will be glad to give these cuts to each author requesting his, or to any responsible institution after authors have had the present opportunity to claim their own. We ask for any such blanket proposition.

We dislike very much to destroy the cuts but storage would cost from four to eight dollars per month which the Annals cannot afford to pay.—*The Managing Editor.*

ENTOMOPHAGOUS INSECTS, by CURTIS P. CLAUSEN. Pages x+688, 257 figs., 6 x 9 inches. 1940. Published by McGRAW-HILL BOOK COMPANY, 330 West 42nd St., New York, N. Y. Linen bound, price $7.00.

The extent of the field covered by this large volume perhaps can be best shown through an indirect Oriental approach. We begin with the bibliography. This cites only literature referred to in the text and even with that limitation covers 47 pages with a total of a thousand or more references. The two-column index in six-point type covers 26 pages! Further it is a book without chapters. Technically this makes it an encyclopaedia.

The volume is a review of the author's experience and the experience of the various staffs on which he has worked on entomophagous insects. As noticed above it reviews also data from one thousand items of the very extensive literature on such forms. It is a volume of habits, life histories and the odd anatomical structures associated with unusual habits. To quote the author's preface: "The literature dealing with entomophagous insects is assuming formidable proportions, and the fieldworker or student has access to only an exceedingly small fraction of the publications. . . . The present volume represents, as nearly as possible, what the author himself would like to have had available while engaged in field work upon insect parasitology and the biological control of insect pests. . . . Particular attention has been given to those groups which reveal a high degree of specialization in their host relationships and in the form of the immature stages to adapt themselves to this mode of life. The generalized predators, consequently, are dealt with briefly and only sufficiently to illustrate the host preferences and habits of each group."

In glancing through the table of contents we find all the orders listed except the Homoptera. As far as is known these are wholly phytophagous. With those orders where entomophagous habits are extensive the subject matter is treated by families. It is interesting to see the number of pages devoted to the several important orders. The Hymenoptera have slightly more than half the volume, 340 pages. The Diptera are next with 142 pages. Then follow the Coleoptera with 61 pages, the Lepidoptera with 13 pages, the Strepsiptera with 25 pages, then twelve or more of the smaller orders with much shorter accounts.

The general organization is taxonomic and not along philosophical lines according to types of habits or the philosophy of usefulness to man. It is a volume of demonstrated facts although under each of the many species treated the types of parasitism or predatism are discussed and commented upon freely. Each order opens with a general summary of habits and structure which is a general review. That opening the section on Hymenoptera is seventeen pages long, that on Diptera nine pages in extent. But in the volume of 688 pages not much space is devoted to generalizations. We see the work as a most valuable scientific review of the subject but the first of its extent in the field and hence dealing with a branch of science which is as yet largely a mass of only partially digested and partially organized facts. It has taken long years of experience, endless work and courage on the part of the author to tackle such a problem.

This becomes at once an authoritative work, first, from the very meticulous manner in which data have been assembled from the carefully chosen literature and, secondly, from the experience of the author whose whole professional life has been spent not only with leaders in this field but in the very fore-front of biological control activities. Clausen received his B. S. degree in entomology at the University of California in 1914. The following year he was Assistant Entomologist at the Citrus Experiment Station. He had the best start possible in his career on biological control under Professor Harry S. Smith. From 1916–18 he was Assistant Superintendent of the State Insectary (Calif.). In 1920 he entered the U. S. Bureau of Entomology and was sent to Japan and the Orient in charge of the study and collection of enemies of the Japanese beetle. Eventually he was returned to Washington where in 1934 he was placed in charge of the division for parasite introduction. In American entomology he has been continuously in biological control.

This work is a landmark in entomological work in America. A copy should be in the hands of every professional entomologist. It is also a gold mine of interesting habits for teachers of biology.—C. H. K.

THE RELATION BETWEEN EXPOSURE TIME, CONCENTRATION AND TOXICITY IN EXPERIMENTS ON INSECTICIDES

C. I. Bliss,
Sandusky, Ohio

Many toxicological experiments with insects involve at least three factors: the concentration of poison, the length of exposure and the percentage effect. The percentage effect may be related to either of the first two variables by the dosage-mortality curve, using methods of computation which have been described elsewhere. Equations have also been reported which relate concentration and time at a constant mortality. The restriction of an investigation to any two of these three factors, however, is an unnecessary limitation even though at times it may be an experimental convenience. The combination of the three variables presents a problem that is both interesting and practical.

In determining the toxicity of poisons, the time factor may be involved not only as a stimulus, such that the length of exposure to a given concentration determines the amount fixed within the organism, but also as the measured response to a given dose of poison which may or may not involve a time factor in its administration. The first is typified by dosage-mortality data, in which the reaction is measured by the percentage mortality or, more generally, the percentage effect and the results are computed in terms of the dosage-mortality curve (3). In the second the reaction of each individual is timed and the results for each series combined in a time-mortality curve (4). Of the two, the percentage effect provides the more unequivocal criterion and is less subject to individual peculiarities in the mode of toxic action. Both follow parallel relations between concentration and time but only dosage-mortality data will be considered here. Except where noted, statistical procedures have been based upon the standard methods described by R. A. Fisher in "Statistical Methods for Research Workers," with such algebraic transformations as have proved useful.

RELATION BETWEEN CONCENTRATION AND TIME AT A SINGLE LEVEL OF EFFECT

Since any three-factor solution must be consistent with all combinations of two terms in which the third is held constant, the relation of concentration and time for a single level of effect may be considered first. The equation relating concentration and time which seems to have the widest applicability is that proposed by Ostwald (19). For a given level of effect this provides that

$$(C-C_o)^n t=k, \qquad \ldots\ldots(1)$$

where C is the observed concentration of chemical, C_o is a threshold concentration computed from the results of the experiment, t is the length of exposure and n and k are constants.[1] Not infrequently practical considerations restrict the dosage range of an experiment, so that the threshold concentration, if such exists, may be indistinguishable from zero and Eq. (1) then reduces to the simpler

$$C^n t=k \qquad \ldots\ldots(1a)$$

Recently Busvine (9) has proposed that Eq. (1a) be adopted as the standard for evaluating fumigants. For a general discussion of this and related formulae Clark's monograph (11) may be consulted. It is sufficient to note here that the equation is not without a physicochemical basis, although its exact interpretation may be modified by a knowledge of the amount of poison actually absorbed during treatment, such as has been measured by Moore and Carpenter (10) at reduced pressures.

The presence of a measurable threshold concentration, C_o, which would require the use of Eq. (1) instead of the simpler Eq. (1a) can be determined in most cases by graphic analysis. The logarithm of time for a given level of effect is plotted against the logarithm of concentration and a line drawn by inspection through the plotted points. This curve may take two principal forms. (1) All points may fall at random about a straight line, in which case no threshold concentration need be determined and the simpler Eq. (1a) can be used. In some series two or more straight lines differing in slope may be indicated and then Eq. (1a) is applied successively to each segment. (2) The diagram may form a smooth concave curve, especially at the lower concentrations, that can be attributed to a threshold value and requires the solution of Eq. (1). Although statistical tests for the presence or absence of curva-

[1]The n in this equation is the symbol used by Clark (11) and other writers. It should not be confused with a subsequent use of the same symbol n for degrees of freedom in accord with Fisher's notation.

ture are of value when in doubt, the simpler graphic analysis is usually equally sensitive as a criterion of linearity.

LOG-TIME A RECTILINEAR FUNCTION OF LOG-CONCENTRATION

In many cases the logarithm of exposure time plotted against the logarithm of the concentration can be fitted by a single straight line. Then Eq. (1a), in terms of logarithms, is the equation for this line,

$$n \log C + \log t = \log k,$$

or, more conveniently,

$$z + b_2 x = a_2, \qquad \ldots\ldots (2)$$

where z and x are the logarithms of the observed time and concentration respectively, b_2 is the regression coefficient or slope of the straight line relating z and x, and a_2 is the value of z at $x=0$. The parameters b_2 and a_2 of Eq. (2) can be determined from the straight line fitted by inspection but their computation by least squares is to be preferred.

In some instances the plotted points in the diagram of z against x may fall into two (or more) rectilinear segments with a more or less pronounced change in slope at their common end. A line is then fitted to each section separately and each is characterized by its own values of a_2 and b_2 applicable within a restricted range of concentrations. As noted by Gause (13), a single toxic material may act upon the organism in several different ways. Over one range of concentrations one mode of toxic action may limit its effectiveness, to be replaced by a different kind of action as the concentration exceeds this range. Graphic analysis aids in identifying such discontinuities but they seldom occur when the range of concentrations is limited.

The computation of Eq. (2) is simplest when weighting coefficients can be avoided. The exposure time killing some given percentage, such as "100 per cent," may be determined directly for each concentration and then each observation has presumably the same reliability. It is used separately without averaging and without weighting coefficients in calculating the parameters of Eq. (2) by the formulae:

$$[x^2] = S(x^2) - \bar{x}\, S(x) \qquad \ldots\ldots (3)$$

$$[xz] = \bar{z}\, S(x) - S(xz) \qquad \ldots\ldots (4)$$

$$b_2 = \frac{[xz]}{[x^2]} \qquad \ldots\ldots (5)$$

$$a_2 = \bar{z} + b_2 \bar{x}, \qquad \ldots\ldots (6)$$

where $\bar{x}$ and $\bar{z}$ are the mean log-concentration and mean log-time

respectively and S means "sum of." In using these formulae, two more decimal places should be retained in $\overline{x}$ and $\overline{z}$ than are required in the final result.

Since b_2 and a_2 define the relation between exposure time and a given range of concentrations, they are logical units for comparisons of toxicity. The regression coefficient b_2 is a ratio of logarithms, so that it is determined by the rate at which exposure time must be changed relative to the concentration and is independent of the absolute units in which time and concentration are measured. When $b_2 = 1$, either time or concentration can be increased by the same percentage to obtain a given increase in dosage. X-rays, for example, produce an effect determined by the product of intensity and length of exposure. In such cases the equation can be written as $C\ t = k$ and in this form it is sometimes known as "Haber's formula." Peters (20) has applied Haber's formula to a number of chemical poisons but has not demonstrated that b_2 was equal to unity in his examples. With many chemical poisons b_2 is not equal to unity and Busvine (9) found that for ethylene oxide it differed from one species to another. When greater than 1, a given increase in dosage can be obtained by a proportionately smaller increase in concentration than in the exposure period. The reverse is true when b_2 is less than 1. Since less additional poison is required to obtain a given increase in toxicity with larger values of b_2, toxicity is directly proportional to b_2. However, Bliss and Broadbent (7) noted that this criterion may vary with the level of mortality, so that the latter should also be specified.

The value of a_2 depends upon the toxicity of the poison, the level of effectiveness (per cent mortality) and the units in which time and concentration are measured. The latter vary from one investigator to another and could be standardized to advantage in metric units. Numerically, the anti-logarithm of a_2 (k in Eq. 1a) is the time required to fix a given dose of poison when the concentration is equal to one unit (1 g/m^3, 1 millimole/liter, etc.), assuming that the equation is valid at this concentration. Toxicity, therefore, is an inverse function of a_2 or k within any given system of time and concentration units.

Sometimes the experimental technique is reversed and the concentration producing a given mortality is determined for each of several exposure periods. In this case x and z are interchanged in solving equations (2) to (6), leading to the expression of $C\ t^{n'} = k'$ instead of $C^n\ t = k$ of Eq. (1a). Moore (18) has used this form in expressing the toxicity of hydrocyanic acid gas to red scale but the original equation is better known and has important advantages when a threshold concentration must be determined. In computing either type the factor which is

controlled experimentally should appear in the denominator of Eq. (5) but the final relation should be expressed in the form of equation (2) or (1a). When calculated with symbols reversed, the equation can be transformed by dividing all terms by the computed regression coefficient.

The above relation between concentration and exposure time is not restricted to a single level of effectiveness but has been found to hold for both 50 and "100" per cent mortalities as well as for intermediate kills. Many entomologists prefer the so-called "100 per cent" mortality because of its approach to the practical requirements of insect control. The vagueness of this level is not always appreciated. In some cases, for example, 10 individuals have been used for each determination and the curve relating concentration and exposure time drawn free hand so as to divide the observations with one or more survivors from those without survivors (20). In typical diagrams of this sort, less than 15 per cent of the values bordering the curve may fall on the wrong side of the boundary. Yet one should not assume that these curves represent 100 per cent kill. With 10 individuals for each determination they bisect the region between 90 and 100 per cent and are probably nearer to 95 than to the supposed 100 per cent. The case is similar with other determinations of total mortality. With closely spaced observations, the experimenter may determine with fair precision the dosage killing a percentage approaching 100 but limited by the size of the individual sample to some smaller value. Sometimes it is more practicable experimentally to classify each lot after treatment as either with or without survivors without counting the total number. This may be justified when the separate lots number one hundred or more and are fairly uniform in size as in the case of insect eggs or mites, but when the experimental material is limited, it is more efficient to work with the smaller mortalities forming a series of dosage-mortality curves.

Determination of linearity. In the above procedure the relation between log-time and log-concentration has been assumed to follow a straight line. Any consistent curvature usually can be recognized on inspection, but when the curvature is not pronounced or the data are irregular, it is desirable to supplement the graphic analysis by a statistical test. The method consists of adding a term representing curvature in a single direction to the equation for a straight line and then determining whether the enlarged formula accounts for substantially more of the total variation than the original straight line. This additional term is the coefficient b' for the square of the log-concentration, x^2. The enlarged formula, known as a polynomial, is a favorite among statisticians because of its flexibility and ease of calculation which adapt it to a test for curvature.

The first step is to recompute the enlarged equation relating log-concentration and log-time. For this purpose the following additional sums of deviations from their respective means are required:

$$[x^3] = S(x^3) - \bar{x}\, S(x^2), \qquad \ldots\ldots(7)$$

$$[x^4] = S(x^4) - \bar{x^2}\, S(x^2) \qquad \ldots\ldots(8)$$

and

$$[x^2 z] = \bar{z}\, S(x^2) - S(x^2 z), \qquad \ldots\ldots(9)$$

where x^2 is used in the same way as x in the preceding equations. Two partial regression coefficients are then computed,

$$b_p = \frac{[x^4]\,[xz] - [x^3]\,[x^2 z]}{[x^2]\,[x^4] - [x^3]^2} \qquad \ldots\ldots(10)$$

and

$$b_p' = \frac{[x^2]\,[x^2 z] - [x^3]\,[xz]}{[x^2]\,[x^4] - [x^3]^2}, \qquad \ldots\ldots(11)$$

and substituted in the polynomial

$$z + b_p x + b_p' x^2 = a. \qquad \ldots\ldots(12)$$

Since this empirical curve is not to be used descriptively, it is unnecessary to determine the third parameter, a.

The several factors in the experiment can be compared most satisfactorily by the analysis of variance. By this procedure the total variation in the dependent variate of the experiment, which is

$$[z^2] = S(z^2) - \bar{z}\, S(z), \qquad \ldots\ldots(13)$$

is divided into three portions: (a) that due to differences in the log-concentration, x, insofar as they can be accounted for by the straight line in Eq. (2), (b) that due to systematic curvature from this line representing the improvement in fit following the substitution of the curve of Eq. (12) for a straight line and (c) the remaining or residual variation in z. The degrees of freedom and the calculation of the sum of squares for each component are shown in Table I, where N' is the total number of observations.

Each sum of squares is divided by its degrees of freedom to obtain the corresponding mean square or variance. The significant term is the ratio of the variance for the quadratic coefficient to that for the error. When this ratio is less than 1.7, the curvature is usually negligible and Eq. (2) can be used with sufficient accuracy over the observed range of dosages. When the variance ratio exceeds 1.7, it may be referred to Table V in Fisher and Yates (12) to determine its relation to the result expected at the 20 per cent point of significance. If it exceeds this

value and b_p' is negative, the curve described in the following section may prove more satisfactory. A relatively low level of significance has been chosen on the biological grounds that the linear relation of Eq. (1a) or (2) is presumably an experimental simplification which would be untenable if the concentration were reduced sufficiently. Hence one would not need to disprove the rectilinear relation statistically before preferring a more adequate alternative. On the other hand, if the quadratic term is not substantially larger than the error, the data probably do not justify the estimation of a threshold concentration, C_o.

TABLE I

STATISTICAL TEST FOR SUSPECTED CURVATURE; FORMULAE FOR COMPUTING THE SUMS OF SQUARES FOR AN ANALYSIS OF VARIANCE

Variation Due to	Degrees of Freedom	Sum of Squares	Equations
Straight-line relation between z and x, the linear term..	1	$b_2[xz]$	(4) (5)
Single curvature from straight line, the quadratic term....	1	$b_p[xz] + b_p'[x^2z] - b_2[xz]$	+ (9) (10) (11)
Other factors or error.....	$N' - 3$	Remainder by difference	
Total.....	$N' - 1$	$[z^2]$	(13)

Precision of the parameters a_2 and b_2. The experimentally determined parameters a_2 and b_2 are estimates of unknown true values and as estimates vary in precision from one experiment to another. Their precision depends in large part upon s^2, the variance measuring the scatter of the individual observations about the line computed from Eq. (2). Then

$$s^2 = \frac{[z^2] - b_2[xz]}{N-2}, \qquad \ldots\ldots(14)$$

where x and z are interchanged if the exposure time instead of the concentration has been held constant in conducting the experiment.

The variance of the regression coefficient, b_2, may then be computed as

$$V(b_2) = \frac{s^2}{[x^2]}, \qquad \ldots\ldots(15)$$

TABLE II

CALCULATION OF TOXICITY OF HYDROGEN SULFIDE TO THE FLOUR MITE FOR "100 PERCENT" MORTALITY, 1936, INSTITUTE FOR PLANT PROTECTION, ROSTOV-ON-DON, U. S. S. R.; CONCENTRATION MULTIPLIED BY 0.1 BEFORE TRANSFORMING TO LOGARITHMS TO REDUCE THE ARITHMETIC

Concentration of H_2S in g/m^3	Exposure Time in Hours	Log-0.1 (g/m^3) x	Log-Hours z	x^2
750	0.25	1.875	—0.602	3.515625
500	0.50	1.699	—0.301	2.886601
250	1.0	1.398	0	1.954404
80	4.0	0.903	0.602	0.815409
30	18.0	0.477	1.255	0.227529
20	24.0	0.301	1.380	0.090601
Total.....	.....	6.653	2.334	9.490169

Calculation of Eq. (2) for straight line in Fig. 1:

$$\bar{x} = \frac{6.653}{6} = 1.1088333 \qquad [x^2] = 9.490169 - (1.1088333)(6.653) = 2.11310$$

$$\bar{z} = \frac{2.334}{6} = 0.3890000 \qquad [xz] = (0.3890)(6.653) - (-0.082528) = 2.67054$$

$$b_2 = \frac{2.67054}{2.11310} = 1.26380 \qquad a_2 = 0.3890 + (1.26380)(2.10883) = 3.0541$$

($\bar{x}$ corrected to log. of original units)

Solution of Eq. (7)–(11), (13) for test of linearity in Table 3:

$$\overline{x^2} = \frac{9.490169}{6} = 1.5816948 \qquad [x^3] = 15.100505 - (1.1088333)(9.490169) = 4.57749$$

$$[x^2][x^4] - [x^3]^2 = 0.65536 \qquad [x^4] = 25.236649 - (1.5816948)(9.490169) = 10.22610$$

$$[x^2z] = (0.3890)(9.490169) - (-2.083819) = 5.77549$$

$$[z^2] = 4.294834 - (0.3890)(2.334) = 3.38691$$

$$b_p = \frac{(10.22610)(2.67054) - (4.57749)(5.77549)}{0.65536} = 1.3305$$

$$b_p' = \frac{(2.11310)(5.77549) - (4.57749)(2.67054)}{0.65536} = -0.0308$$

its standard error being the square root of the variance. For the parameter a_2 it is convenient to use the variance about the line at the mean concentration $\bar{x}$. This is equal to

$$V(a_2) = \frac{s^2}{N} \qquad \ldots\ldots(16)$$

and is valid at or near the center of the curve, so that $\bar{x}$ should be specified. At concentrations differing considerably from the mean, the error in the slope is also of importance and the variance of an expected z near the ends of the curve is given by the expression

$$V(z) = V(a_2) + V(b_2)\ (x - \bar{x}) \qquad \ldots\ldots(17)$$

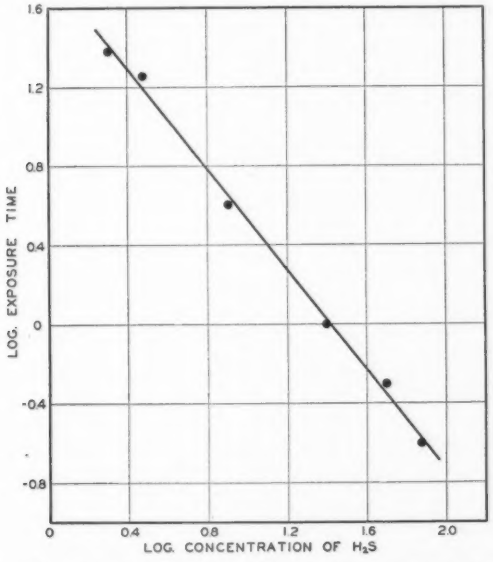


FIG. 1. Toxicity of hydrogen sulfide to the flour mite, from the data in Table II. In original units, the equation of the straight line is $C^{1.26}t = 1130$.

Numerical examples. The calculation may be illustrated by an experiment on the toxicity of hydrogen sulfide to flour mites from the Institute for Plant Protection, Rostov-on-Don, USSR. Table II gives the exposure period in hours at which "100 per cent" mortality was observed for each of six concentrations. These units have been transformed to logarithms and plotted in Fig. 1, the plotted points agreeing

substantially with the straight line. Stages in computing this line with Eq. (3) to (6) are given below Table II, the final equation being $z+1.264\,x=3.054$ or, in original units, $C^{1.26}t=1130$. Experimentally mites are probably well adapted to determinations of "100 per cent" kill, the true mortality in the present case probably falling within one-half per cent of this level.

The relation of log-exposure time to log-concentration as plotted in Fig. 1 was so clearly linear that the graphic evidence could be accepted without hesitation, but it has been verified to illustrate the calculation. The sums of the higher powers and products were obtained directly by

TABLE III

ANALYSIS OF VARIANCE FOR TESTING LINEARITY OF RELATION BETWEEN LOG-CONCENTRATION AND LOG-TIME FOR THE DATA IN TABLE II

Variation Due to	Degrees of Freedom	Sum of Squares	Mean Square
Straight line in Fig. 1, the linear term....	1	3.3750	3.3750
Single curvature, the quadratic term....	1	0.0002	0.0002
Error.....	3	0.0117	0.0039
Total.....	5	3.3869	

accumulating the products of the appropriate columns of Table II in the calculator. These were then substituted in Eq. (7) to (9) as shown below the table to obtain the remaining terms needed in computing the partial regression coefficients by Eq. (10) and (11). With the formulae in Table I and the numbers in Table II, the analysis of variance was completed in Table III. The quadratic term was even less than the mean square for error, confirming the suitability of a straight line for fitting the observations plotted in Fig. 1.

The precision of this line was determined by computing

$$s^2 = \frac{3.38691-(1.26380)\,(2.67054)}{6-2} = 0.002966 \text{ from Eq. (14)}$$

$$V(b_2) = \frac{0.002966}{2.11310} = 0.001403 \text{ from Eq. (15)}$$

$$V(a_2) = \frac{0.002966}{6} = 0.0004943 \text{ at } x=2{,}1088 \text{ from Eq. (16).}$$

Extracting square roots to transform variances to their respective standard errors, the parameters of the straight line relating log-hours exposed to log-concentration in g/m^3 were $b_2 = 1.264 \pm 0.037$ and $a_2 = 3.054 \pm 0.022$, $\bar{x}$ being 2.1088.

An example of the same general relation at a lower level of mortality is that reported by Hoskins (15). Mosquito pupae were immersed in three molal concentrations of sodium arsenate for different exposure

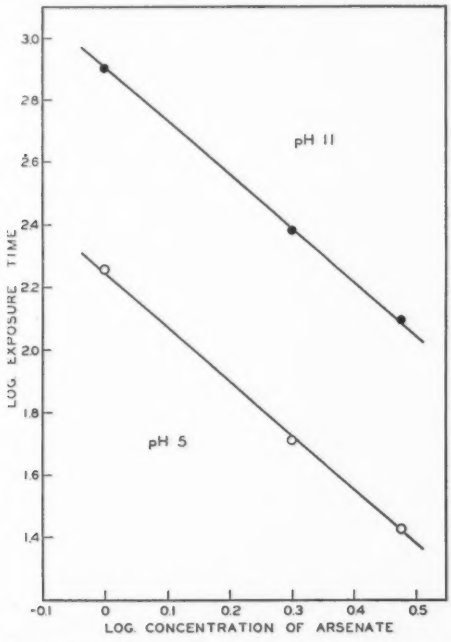


FIG. 2. Toxicity of sodium arsenate to mosquito pupae at different hydrogen ion concentrations, as reported by Hoskins (15). The equations of the parallel lines are $C^{1.73}t = 176$ at pH 5 and $C^{1.73}t = 807$ at pH 11, pH 5 being 2.41 times as toxic as pH 11.

periods. The observed percentage mortalities were plotted against the exposure time in a series of sigmoid curves and the minutes required to kill 50 per cent interpolated graphically. The experiment was duplicated in solutions of pH 5 and pH 11 with the results plotted in Fig. 2. Since the two series of plotted points were substantially parallel, a combined regression coefficient has been computed from the sums of the numerators and of the denominators for the separate curves to obtain an improved value applying to both hydrogen ion concentrations.

Then

$$z+1.730x=2.246 \text{ or } C^{1.73}t=176 \text{ at pH } 5$$

and $$z+1.730x=2.907 \text{ or } C^{1.73}t=807 \text{ at pH } 11.$$

Two parallel straight lines such as here is the desired objective in the comparison of toxicities as described elsewhere (8). The log-ratio of equitoxic concentrations of arsenical was $\frac{2.907-2.246}{1.730} = 0.382$, so that the solution was 2.41 times as toxic at pH 5 as at pH 11.

LOG-TIME A CURVILINEAR FUNCTION OF LOG-CONCENTRATION

When the diagram of log-time plotted against log-concentration is not a straight line, it usually describes a concave curve, especially at the lower concentrations. In this case the general relation shown in Eq. (1) may be used. The slope b_2 and the position a_2 are supplemented by a third parameter, C_o, which is the threshold concentration or physiological zero for a given mode of toxic action. C_o is sometimes defined as the largest concentration which does not produce death under prolonged exposure but can be balanced physiologically by the organism. In practice, however, C_o is seldom determined experimentally. Rather it is the concentration which satisfies the equation, so that the log-time, z, can be plotted as a straight line against the logarithm of $(C-C_o)$, the equation being written as

$$\log t+b_2 \log (C-C_o)=a_2$$

or

$$z+b_2x_{1,\,2,\,\ldots n}=a_2\,, \qquad \ldots\ldots(18)$$

where $\log (C-C_o)$ is designated by the letter x with a separate subscript for each successive value of C_o required for a complete solution.

There is probably no practicable method for computing the three terms, C_o, a_2 and b_2 in a single step. One must proceed indirectly by successive approximations until a value of C_o is found such that z plotted against $x_{1,\,2..n}$ does give a straight line. As a starter C_o may be assigned some number midway between zero and the smallest concentration tested in the experiment. This provisional value is subtracted in turn from each actual concentration and the differences changed to logarithms to obtain the first estimate of the logarithm of the effective dose, x_1. Log-time (z) is then plotted against x_1. If the curve still retains its original concave form, even though less pronounced, a still larger C_o is indicated but if the curvature has been reversed, C_o has been overestimated. With the aid of this information, a second shot of C_o can be tested similarly in terms of z and x_2. The process is continued

until a value of C_o is obtained which gives a straight line in terms of z and x_n. If, for example, this objective should be reached with the fourth estimate of C_o, the remaining two parameters, a_2 and b_2, would be computed from the values of z and x_4 as described in the preceding section.

There are several disadvantages, however, in a purely graphic estimate of C_o. Unless the data are unusually uniform, its value can be determined only approximately; without a numerical method for recognizing the correct value an unnecessarily large number of estimates may have to be tried; the standard error cannot be estimated satisfactorily for any of the parameters. These limitations can be avoided by the test for linearity given in a preceding section.

By definition the correct value of C_o is that which brings all values of z into a straight line when plotted against log $(C-C_o)$, and this line can be considered straight when the coefficient for the quadratic term, b_p', in Eq. (12) is equal exactly to zero. As long as a diagram of z against x_n retains some of the original concave curvature, b_p' will be a small, negative number and C_o should be increased. When b_p' is positive, the original curvature has been reversed and C_o should be reduced. For each successive estimate of C_o, b_p' is computed by Eq. (11) from z and $x_1, x_2 \ldots x_n$. It is desirable that C_o be selected so that one of the first two estimates of b_p' is positive and the other negative. Then by linear interpolation, C_o can be estimated for $b_p'=0$ and used in determining x_3.

Since it is not a linear function of C_o, the b_p' computed from z and x_3 will not be equal to zero, but by plotting the three values of b_p' against the corresponding C_o and connecting them by a smooth curve, C_o can be interpolated at $b_p'=0$ with as high a precision as one needs. This final estimate is subtracted in turn from each observed concentration, the differences changed to logarithms to obtain x_4 and the remaining two parameters, a_2 and b_2, computed by Eq. (3) to (6). It may be noted in using this method that experimentally the exposure times should be the dependent variable, not the concentrations.

Sometimes the above procedure may not bring all of the observations into line, which could occur if there were more than one predominant type of toxic action within the range of concentrations covered by the experiment. Log t plotted against log $(C-C_o)$ may fall into two rectilinear segments, both having apparently the same threshold concentration, or into a rectilinear section at the lower concentrations succeeded by a discordant group of observations which still retain some of the original concavity. In the latter case all three parameters, C_o, b_2 and a_2, should be computed separately for each section, there being no theoretical or statistical necessity for different modes of toxic action to have the same threshold concentration.

Precision of the equation. Although Eq. (18) is not a parabola, its parameters have been computed with the aid of a parabola and their precision is determined by this fact. The variance s^2 has one less degree of freedom than before and is equal to

$$s^2 = \frac{[z^2] - b_2 [x_4 z]}{N-3} . \qquad \ldots\ldots (19)$$

When C_o is greater than zero, the variance of the regression coefficient b_2 equals that for the corresponding polynomial coefficient, b_p, or

$$V(b_2) = V(b_p) = \frac{s^2 [x_4{}^4]}{[x_4{}^2][x_4{}^4] - [x_4{}^3]^2}, \qquad \ldots\ldots (20)$$

the denominator being that used in computing the final estimate of b_p' as indicated by the subscript "$_4$".

The variance of C_o depends upon that for the polynomial coefficient b_p', which is equal to

$$V(b_p') = \frac{s^2 [x_4{}^2]}{]x_4{}^2][x_4{}^4] - [x_4{}^3]^2} . \qquad \ldots\ldots (21)$$

The standard error of b_p' or $\sqrt{V(b_p')}$ is referred to the curve of b_p' vs. C_o and by interpolating at $+\sqrt{V(b_p')}$ and at $-\sqrt{V(b_p')}$, the limits of C_o corresponding to its standard error are read directly in units of concentration.

The variance of a_2 at or near $\overline{z}_4$ is unchanged from that given before and is computed from Eq. (16).

TABLE IV

ORIGINAL DATA AND THEIR TRANSFORMATION FOR COMPUTING THE TOXICITY OF HYDROCYANIC ACID TO THE COCKROACH FOR "100 PERCENT" MORTALITY FROM EXPERIMENTS REPORTED BY ALLISON (1)

Percent Concentration C	Minutes Exposed t	Log. $t/_{10}$ z	C—0.02	Log. 100 (C—0.02) x_1	$x_1{}^2$	Log. 100 (C—0.0218) x_4
0.0407	180	1.255	0.0207	0.316	0.099856	0.276
0.0505	120	1.079	0.0305	0.484	0.234256	0.458
0.0563	120	1.079	0.0363	0.560	0.313600	0.538
0.0660	90	0.954	0.0460	0.663	0.439569	0.645
0.0689	105	1.021	0.0489	0.689	0.474721	0.673
0.0764	90	0.954	0.0564	0.751	0.564001	0.737
0.0869	75	0.875	0.0669	0.825	0.680625	0.814
0.1435	50	0.699	0.1235	1.091	1.190281	1.085
0.1620	40	0.602	0.1420	1.152	1.327104	1.146
0.2035	35	0.544	0.1835	1.262	1.592644	1.259
0.3523	25	0.398	0.3323	1.521	2.313441	1.519

Numerical example. The above relation is illustrated by experiments on the toxicity of hydrocyanic acid to cockroaches by Allison (1), who reported the exposure time for "100 per cent" mortality at each of eleven concentrations. The original measurements in the first two columns of Table IV have been plotted in logarithmic units in Fig. 3. The trend of the observations was clearly curvilinear. Since the smallest concentration was 0.0407 per cent of HCN, 0.02 was adopted for the first estimate of C_o, subtracted from each concentration and the differences changed to logarithms to obtain x_1 in column 5 of Table IV.

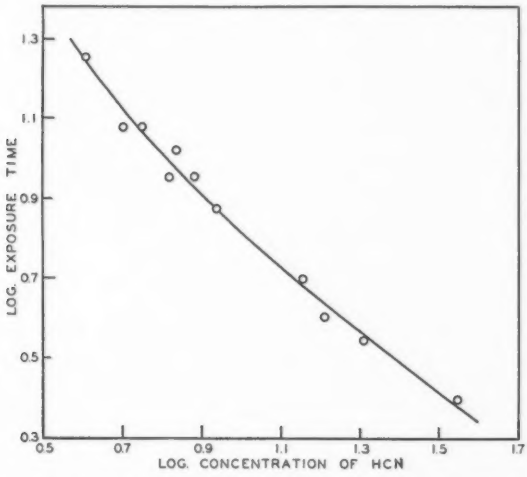


FIG. 3. Toxicity of hydrocyanic acid to the cockroach, from data in Table IV as reported by Allison (1). The equation of the curve is $(C - 0.0218)^{0.698}t = 11.08$.

The polynomial coefficient b_p' was then computed from the columns of x_1 and z in Table IV, as given in the first column of Table V. The first coefficient was negative, $b_p' = -0.02396$, so that a still larger C_o ($=0.03$) was selected for second estimate. The second estimate was positive, $b_p' = 0.06794$, and linear interpolation between the two gave the third estimate of $C_o = 0.0226$, which led to the coefficient $b_p' = 0.00949$. The three values of b_p' were then plotted against the assumed threshold concentrations C_o (Fig. 4) and the points connected by a smooth curve. Graphic interpolation from the curve gave the final estimate of $C_o = 0.0218$, which has been subtracted from each of the observed concentrations and changed to logarithms to obtain the x_4 in the last column of

Table IV. The computation in the last column of Table V checked this estimate, giving $b_p' = -0.00007$ or substantially zero. The remaining parameters, b_2 and a_2, were computed from x_4 and z by Eq. (5) and (6) as $b_2 = \frac{0.99236}{1.42195} = 0.6979$ and $a_2 = 1.860 + (0.6979)\ (-1.1682) = 1.0447$ in terms of logarithms of the original units, before change in decimal point to facilitate the computation. In terms of x_4 and z, b_2 and a_2 define the straight line plotted in Fig. 5 and in terms of x_0 and z the curve shown in Fig. 3. The final equation was $\log t + 0.698 \log (C - 0.0218) = 1.0447$ or $(C - 0.0218)^{0.698} t = 11.08$.

TABLE V

COMPUTATION OF THE THRESHOLD CONCENTRATION C_0 BY SUCCESSIVE APPROXIMATIONS FROM THE DATA IN TABLE IV

Parameter	Results for Threshold Concentration of C_0 and x_n			
	0.02 x_1	0.03 x_2	0.0226 x_3	0.0218 x_4
$S(z)$	9.460	9.460	9.460	9.460
$\overline{z}$	0.860	0.860	0.860	0.860
$S(x_n)$	9.314	8.402	9.075	9.150
$\overline{x}_n$	0.8467273	0.7638182	0.8250000	0.8318182
$S(x_n^2)$	9.230098	8.519786	8.944647	9.033086
$\overline{x_n}^2$	0.8390998	0.7745260	0.8131497	0.8211896
$[x_n^2]$	1.343680	2.102185	1.457772	1.421949
$[x_n^3]$	2.464853	3.393336	2.593772	2.554606
$[x_n^4]$	4.684643	5.893009	4.811394	4.775047
$[x_n z]$	0.964685	1.201653	1.004728	0.992360
$[x_n^2 z]$	1.765715	1.967930	1.789547	1.782814
$[x_n^2]\ [x_n^4] - [x_n^3]^2$	0.219161	0.873466	0.286262	0.263861
b_p'	−0.02396	0.06794	0.00949	−0.00007

The standard errors of all three parameters depended upon the variation in z about the curves of Figs. 3 or 5, computed as $s^2 = \frac{0.70155 - (0.69789)\ (0.99236)}{11 - 3} = 0.0011244$. With s^2 and the terms in the last column of Table V, the variance of b_2 was determined from Eq.

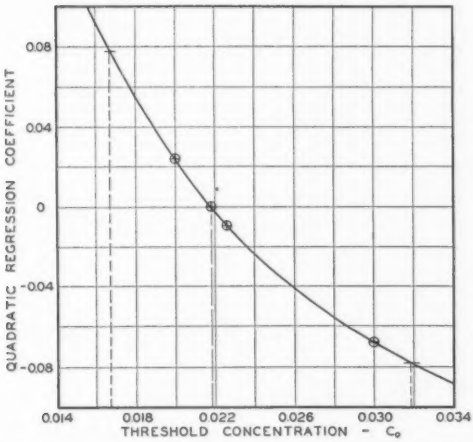


FIG. 4. Graphic analysis of the relation between the quadratic regression coefficient, b_p', computed in Table 5, and the threshold concentration, C_o, of hydrocyanic acid for the cockroach; used to determine the value of C_o which gives a straight line when the log-exposure time is plotted against the log-effective concentration, as in Fig. 5.

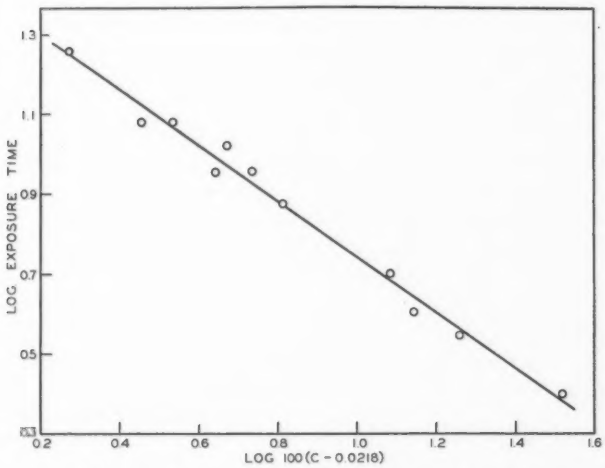


FIG. 5. Data on the toxicity of hydrocyanic acid in Fig. 3 replotted against the logarithm of the effective concentration, showing that the estimated C_o has corrected the initial curvature; the curves in both figures have the same equation.

(20) as $V(b_2) = \frac{(0.0011244)\ (4.77505)}{0.26386} = 0.020348$, so that $b_2 = 0.698 \pm 0.143$. To obtain the variance of C_o, $V(b_p') = \frac{(0.0011244)\ (1.42195)}{0.26386} = 0.0060594$ was needed. The square root of this term, $\sqrt{V(b_p')} = 0.0778$, has been interpolated in Fig. 4 to obtain the limits of precision for C_o of 0.017 and 0.032. Since these have been extrapolated from outside the values of C_o which were assumed in its estimation, their accuracy is limited to two significant figures. The variance of the remaining parameter was computed as $V(a_2) = \frac{0.0011244}{11} = 0.00010222$, so that $a_2 = 1.0447 \pm 0.0101$.

RELATION BETWEEN CONCENTRATION, EXPOSURE TIME AND EFFECT

In many cases the relation between concentration and exposure time cannot be determined efficiently at the level of effect where the fumigant is to be used. This occurs whenever a percentage mortality intermediate between 0 and 100 is measured for more than one exposure period at each of several concentrations. The experiment leads to a series of dosage-mortality curves from which the median lethal dose or LD50 can be estimated with somewhat greater precision than other levels of effect but higher or lower levels are often of more concern to the experimenter. The series of dosage-mortality curves can be used both for an improved estimate of the LD50 and also to compute the relation between dosage and other mortalities. A more general formulation should incorporate all of the information in such a family of curves and not just that from a single point on each component.

The development of a suitable equation is based upon two premises: (1) a linear dosage-mortality curve in terms of log-exposure time and probit mortality at each of several concentrations and (2) a linear relation between the logarithm of the effective concentration and the logarithm of exposure time at any given mortality. Both propositions should be tested in the course of the calculation. A linear relation between probit effect and log-dose has been reported for so many toxic agents and organisms that it may be considered the rule and departures from linearity the exception. Occasionally the rectified curve has been observed to flatten more or less abruptly at the lower levels of mortality, usually below 25 per cent kill. Such changes in slope are not unexpected biologically (6) and do not nullify the log-probit diagram.

However, when they occur, they fix a lower limit of effect to the prediction range of equations based upon the observations above the "break." As shown in the preceding sections, the relation between concentration and time can be fitted more easily when the threshold concentration C_o does not differ appreciably from zero, a condition which is sufficiently frequent that it may be assumed provisionally.

A further basic condition, which demands a fastidious technique and a well balanced design, is that all component curves represent individuals of equal inherent susceptibility. The separate lots of organisms, especially between concentrations, should duplicate one another within the sampling error in all respects except the treatment factors of concentration and exposure time.

The dosage-mortality curve is defined by two parameters, its position, a', and slope, b. Although computed in these terms because of the relation between the independent and the dependent variates, it can be used "in reverse" to estimate the dosage producing a required effect. The log-exposure time, z, for a given probit y is determined as

$$z = s(y - a') = \frac{1}{b}(y - \bar{y}) + \bar{z}, \qquad \ldots\ldots(22)$$

where $a' = \bar{y} - b\bar{z}$ or the expected probit at $z = 0$ and $b\left(= \frac{1}{s}\right)$ is the change in y per unit change in z, both computed separately for each concentration. It is clear from Eq. (22) that z depends upon s as well as upon a' and the relation of s to the log-concentration (x) may be used diagnostically to separate the simpler case in which the standard deviation, s, or slope is independent of the concentration from that in which it is a function of the concentration. Sometimes the experimental procedure is reversed and the individual dosage-mortality curves are obtained in units of concentration at given exposure periods, as in the experiments reported by Busvine (9). When this occurs, x and z in the following discussion are interchanged.

RELATION WHEN SLOPE OF THE DOSAGE-MORTALITY CURVE IS INDEPENDENT OF THE CONCENTRATION

A tendency for the slope of the individual dosage-mortality curves to increase or decrease with the concentration usually can be recognized by inspection of the slopes obtained by graphic interpolation or by plotting their reciprocals against the log-concentration to see if the plotted points fall more or less at random above and below a horizontal line. If this shows that the individual values may be considered tentatively as inde-

pendent shots at a single term, the relation between the three variables y, x and z may be solved initially from the provisional dosage-mortality curves. Thus the graphic solution embraces the complete series of curves treated as a whole and the provisional equation is then corrected by computation.

In detail, the procedure is to plot the empirical probit (y) for each percentage against the log-time (z), fit a straight line independently by inspection to the points for each concentration and interpolate z from each line at $y=5$ and at $y=4$. The difference between these interpolated z's is divided into 2 to obtain the slope for each curve, $b = \frac{2}{\triangle z}$. If the slopes do not vary systematically with the concentration, the separate estimates of b are averaged arithmetically. Then the provisional log-LD50's or z's at $y=5$ are plotted against the logarithm of the concentration (x). Unless the diagram indicates a concave curve, the plotted points are fitted by inspection with a straight line from which two points are interpolated and used in solving Eq. (2).

The union of the combined slope, b_c, relating y and z at any x and the equation relating x and z at $y=5$ depends upon the fact that Eq. (2) as a whole then defines the log-LD50 in terms of z. When $x=0$, $z=a_2$, showing that a_2 is in terms of z, while x is multiplied by b_2 to change it into units of z when x is not equal to 0. Eq. (2) can be written in the form

$$z+b_2x-a_2=0 \text{ at } y=5,$$

and when used with values of x and z such that the left side of the equation is greater than zero, the expected mortality will exceed 50 per cent and when the left side is less than zero, the expected mortality must be less than 50 per cent. Any departure from zero will be in terms of z and can be transformed to a difference in probits by multiplying by the combined slope, b_c. Hence it is clear that

$$y=5+b_c(z+b_2x-a_2)$$

since y will be equal to 5 whenever z and x occur in a combination such that the expression within the parenthesis is zero. It is convenient to rearrange the equation to

$$y=(5-b_ca_2)+b_cz+b_cb_2x, \qquad \ldots\ldots(23)$$

giving the relation between mortality in probits and any combination of concentration and exposure time within the dosage range of the original curves in terms of three parameters.

The provisional parameters of Eq. (23) obtained graphically are needed in calculating the corrected estimates. An expected probit is computed for each individual observation by solving Eq. (23) with the logarithms of the observed concentrations and exposure times (x and z). From the expected probit, the observed percentage effect and the number of individuals, a corrected probit (y) and its weight (w) are determined for every observation with the aid of computing tables published elsewhere (5, 12). Occasionally the observed mortality departs so decisively from expectation that the corrected probit may differ by one or two or more probits from the empirical value. When coupled with a significant value of χ^2 for the entire curve, discrepancies of this magnitude are so clearly inconsistent with the rest of the data that it is desirable to segregate them for separate consideration. With these omissions, a dosage-mortality curve is computed for each concentration by the usual technique from the log-exposure times and the corrected probits. This stage of the calculation is completed by testing the agreement between each curve and its component observations by χ^2. Even where χ^2 exceeds the sampling error significantly, the log-probit line based upon a random scatter of observations may still be the best available measure of the relation between dose and effect.

In the absence of any obvious trend between the computed slopes and the concentration, they are considered tentatively as independent estimates of a single slope. The combined value is given by the equation

$$b_c = \frac{S[wzy]}{S[wz^2]} = \frac{1}{s_c}, \qquad \ldots\ldots(24)$$

where $[wzy]$ and $[wz^2]$ are the numerator and denominator respectively of the slope for each component dosage-mortality curve. The combined term s_c is substituted for s in Eq. (22) to determine for each concentration the median lethal exposure time (z at $y=5$), required in solving Eq. (2) for the relation between concentration and time.

The several determinations of log-exposure time, however, seldom have the same validity, so that weights are used to adjust this inequality. The variance of z at any given probit depends upon both the variance in position, $V(a)$, and the variance in slope, $V(b)$. When the more precise combined slope is available, the second component can be omitted without appreciable error, especially if the weighted mean effects ($\bar{y}$) for the individual curves fall within a range of one probit. Hence the variance of each determination can be simplified to the approximate form of $V(a)/b_c^2$ and since the information in any term is the reciprocal of its variance, the reciprocal of this expression could be

used as the weight or $W_2 = b_c^2/V(a)$. But on the present hypothesis, b_c is the same for all curves in a series, so that it can be omitted uniformly from all weights. For homogeneous data $V(a) = 1/S(w)$ and the required weight is $W_2 = S(w)$, where $S(w)$ is the sum of the weights determined in computing each dosage-mortality curve. The same formula for W_2 can be used even when the individual observations comprising each curve are not homogeneous, if the variation as measured by χ^2 does not differ significantly from one concentration to another.

The computation with weights is similar to the procedure for the dosage-mortality curve. For calculating Eq. (2), W_2 is placed immediately before each x and x^2 in Eq. (3) to (5). The computed values of b_c, a_2 and b_2 are then combined in Eq. (23) to obtain the corrected relation between log-concentration, log-exposure time and the expected mortality in probits.

Tests for the agreement between equation and observations. In any given case the validity of Eq. (23) depends upon how closely it duplicates the observed mortalities when solved for each combination of concentration and exposure time tested experimentally. The differences between the computed and observed probits could be squared, each multiplied by its standard weight and the products summed for a χ^2 test of agreement. Although the χ^2 determined in this way would show whether the computed differed significantly from the observed values, it would not locate the source of such a discrepancy. Substantially the same composite result can be obtained more easily by an analysis of variance with the added advantage that it dissects the total variation into its essential components. These are (1) departure from a straight line of the LD50's computed in terms of the log-exposure time for each log-concentration, (2) divergence of the dosage-mortality curves computed individually for each concentration from the combined slope for the entire series, and (3) deviation from the initial dosage-mortality curves of the observed probit mortalities. In practice these three elements are computed in the reverse order of their formulae listed in Table VI, where N is the number of dosage-mortality curves and $S(n)$ the sum of the degrees of freedom in each. There are two fewer degrees of freedom in each curve than the number of percentages upon which it is based, but there is some doubt that all 0 and 100 per cent kills should be counted equally with the remaining observations for this purpose (see Irwin's paper and discussion (16)). When there is less than one chance in five that even a single survivor would be expected with a given treatment, there is some justification for combining the terminal observations in counting the degrees of freedom until this level is reached or exceeded.

The sum of the χ^2's comprising the error measures the variation about the curves fitted individually to the *corrected* probits at each concentration. If the mean square is 1 or less, the results agree within the sampling error and the sums of squares for the other two components are themselves χ^2's and should be evaluated from tables of the χ^2 distribution. If the mean square for error is greater than 1.2, the variation about the individual curves approaches or exceeds the sampling error and the significance of the first two terms in Table VI should be judged in terms of the variance ratio (12) or of Snedecor's "F" (22).

TABLE VI

STATISTICAL TEST FOR AGREEMENT WITH EQ. (23); FORMULAE FOR COMPUTING THE SUMS OF SQUARES FOR AN ANALYSIS OF VARIANCE

Variation Due to	Degrees of Freedom	Sum of Squares
(1) Departure from a linear relation between log-concentration and log-time	$N - 2$	$b_c^2([W_2z^2]-b_2[W_2xz])$
(2) Replacing the individual slopes of the dosage-mortality curve by the combined value, b_c	$N - 1$	$S(b[wzy])-b_cS[wzy]$
(3) Scatter of observations about the individual dosage-mortality curves, the error	$S(n)$	$S(\chi^2)=S([wy^2]-b[wzy])$

There is the further stipulation that the variation measured by the component χ^2's should not differ significantly from one curve to another or their combination into a single estimate of error is not justified.*

*Bartlett (2) has given a simple χ^2 test suitable for comparing the χ^2's from a series of dosage-mortality curves. For N separate curves, each represented by its own χ^2 with n degrees of freedom,

$$\text{"crude" } \chi^2 = 2.3026 \left\{ S(n) \log \frac{S(\chi^2)}{S(n)} - S\left(n \log \frac{\chi^2}{n}\right) \right\} . \qquad \ldots.(25)$$

If the "crude" χ^2 with $N - 1$ degrees of freedom appears significant, it should be corrected by dividing by C, where

$$C = 1 + \frac{1}{3(N-1)} \left\{ S\left(\frac{1}{n}\right) - \frac{1}{S(n)} \right\} , \qquad \ldots.(25a)$$

which improves the "crude" value considerably. The "crude" values of χ^2 are additive.

Should the heterogeneity be localized in one or two "bad" dosage-mortality curves, $S(w)$ for each of these may be multiplied by the ratio of n/χ^2 to obtain $W_2 = \dfrac{n\ S(w)}{\chi^2}$, and the sum of squares for the first entry in Table VI treated as a χ^2. The slopes may be compared similarly by χ_b^2, computed as

$$\chi_b^2 = S\left\{\frac{(b-b_c)^2}{V(b)}\right\}, \qquad \ldots\ldots(26)$$

where b and $V(b)$ are the slope and its variance for each component curve. If the slopes of the component curves were to depart significantly from their combined values by any of these tests, one might hesitate to represent the experimental results as a whole by Eq. (23). Should the variation about the straight line relating z and x approach or exceed the level of significance, the deviation of the plotted points from this line should be examined for systematic concave curvature, which would require the determination of C_o and the substitution of Eq. (18) for Eq. (2).

Numerical Example. The toxicity of ethylene oxide to the grain beetle, *Calandra granaria*, has been measured by Busvine (9) at several concentrations for each of six exposure periods. Since the individual dosage-mortality curves were determined in terms of concentration instead of exposure time, or of x and y instead of z and y, x and z have been interchanged throughout in applying the above equations. Busvine's analysis showed a significant variation both of probits about the individual dosage-mortality curves and of the log-LD50's about the straight line of Eq. (2), a variation which he attributes in part to differences in the age of the adult beetles and in the interval between collection and fumigation, points which have since been demonstrated by Gough (14) to be of importance. Examination of the test numbers in a transcript of the original data showed that the dosage-mortality curves for the four intermediate exposure periods were determined more or less in parallel, followed in turn by those for the longest and then the shortest intervals. Starting with the intermediate periods, the beetles used in later determinations of percentage mortality were clearly less susceptible to ethylene oxide than those used earlier in the experiment, a trend which seemed to increase progressively. This led to a significant but spurious appearance of concavity, such as would require ordinarily the computation of C_o, spurious because in statistical language the curvature was confounded with order of treatment, which, in turn, may have been correlated with the age of the beetles or the interval between

collection and fumigation. It is evident how the results of a toxicological investigation may depend upon apparently inconsequential details in the original experimental design. In the present case the trend was

TABLE VII

EXPERIMENTAL DATA AND CALCULATION OF DOSAGE-MORTALITY CURVES FOR EACH EXPOSURE TIME IN TERMS OF LOG-CONCENTRATION OF ETHYLENE OXIDE AND MORTALITY OF *Calandra granaria* IN PROBITS; DATA FROM J. R. BUSVINE (9)

(1) Test No.	(2) Log-Hours z	(3) Log-mg/l. x	(4) No. of Insects	(5) Per-cent Dead	(6) Empir-ical Probit	(7) Ex-pected Probit	(8) Cor-rected Probit y	(9) Weight w	(10) wx	(11) wy
72	0	1.394	30	76.7	5.73	6.49	5.23	8.2	11.4308	42.886
34	.....	1.391	30	100	.....	6.45	6.98	8.6	11.9626	60.028
49	.....	1.362	31	93.5	6.51	6.13	6.43	12.2	16.6164	78.446
23	.....	1.322	30	73.3	5.62	5.69	5.62	16.0	21.1520	89.920
29	.....	1.314	26	88.5	6.20	5.60	6.08	14.5	19.0530	88.160
102	.....	1.260	27	25.9	4.35	5.00	4.40	17.2	21.6720	75.680
24	.....	1.225	31	38.7	4.71	4.61	4.71	18.7	22.9075	88.077
22	.....	1.199	30	56.7	5.17	4.32	5.33	16.1	19.3039	85.813
35a	.....	1.167	31	32.3	4.54	3.97	4.70	13.3	15.5211	62.510
26a	.....	1.033	24	0	.....	2.48	2.13	1.1	1.1363	2.343
25	0.301	1.223	39	100	.....	7.26	7.64	3.2	3.9136	24.448
35b	.....	1.167	28	100	.....	6.64	7.13	6.3	7.3521	44.919
46	.....	1.130	32	84.4	6.01	6.23	5.98	11.5	12.9950	68.770
42	.....	1.117	61	100	.....	6.09	6.72	24.9	27.8133	167.328
85	.....	1.049	35	48.6	4.96	5.33	4.95	21.4	22.4486	105.930
50	.....	1.041	30	63.3	5.34	5.24	5.34	18.7	19.4667	99.858
26b	.....	1.033	34	58.8	5.22	5.15	5.22	21.5	22.2095	112.230
93	.....	1.021	31	25.8	4.35	5.02	4.39	19.7	20.1137	86.483
97	.....	0.954	25	12.0	3.82	4.28	3.90	13.2	12.5928	51.480
101	.....	0.908	31	3.2	3.15	3.77	3.36	11.2	10.1696	37.632
38	0.602	0.991	41	100	.....	7.36	7.73	2.7	2.6757	20.871
41b	.....	0.886	60	100	.....	6.19	6.79	22.4	19.8464	152.096
90b	.....	0.851	31	67.7	5.46	5.81	5.41	15.5	13.1905	83.855
60	.....	0.806	31	80.6	5.86	5.31	5.79	19.1	15.3946	110.589
88	.....	0.740	30	30.0	4.48	4.57	4.48	17.9	13.2460	80.192
100	.....	0.695	30	13.3	3.89	4.07	3.90	13.9	9.6605	54.210
84b	.....	0.613	29	13.8	3.91	3.16	4.61	4.9	3.0037	22.589
76a	.....	0.470	29	6.9	3.52	1.58	61.9	.....	.....	.....
40	0.778	0.724	52	100	.....	5.96	6.63	23.5	17.0140	155.805
68	.....	0.716	29	82.8	5.95	5.87	5.94	13.9	9.9524	82.566
63	.....	0.623	33	45.5	4.89	4.84	4.89	20.8	12.9584	101.712
96b	.....	0.618	29	24.1	4.30	4.78	4.34	18.1	11.1858	78.554
82	.....	0.613	49	61.2	5.28	4.73	5.30	30.4	18.6352	161.120
89	.....	0.519	29	17.2	4.05	3.68	4.15	9.5	4.9305	39.425
83	.....	0.462	49	24.5	4.31	3.05	6.77	.....	.....	.....
141	1.301	0.427	35	100	.....	7.31	7.69	2.6	1.1102	19.994
110	.....	0.422	37	97.3	6.93	7.25	6.78	3.1	1.3082	21.018
104	.....	0.292	31	58.1	5.20	5.81	5.08	15.5	4.5260	78.740
108	.....	0.185	28	17.9	4.08	4.62	4.15	16.9	3.1265	70.135
106	.....	0.143	30	16.7	4.03	4.15	4.04	14.6	2.0878	58.984
142	.....	0.041	29	24.1	4.30	3.02	6.91	.....	.....	.....

TABLE VIII

COMPUTATION OF PARAMETERS FOR DOSAGE-MORTALITY CURVES AND FOR EQ. (2) FROM DATA IN TABLE VII

Row No.	Parameter	Dosage-Mortality Curves for z					
		0	0.301	0.602	0.778	1.301	Sum
	Graphic:						
1	x at $y=5$	1.234	1.039	0.752	0.602	0.248	
2	x at $y=7$	1.394	1.181	0.952	0.838	0.436	Mean =
3	b	12.500	13.889	10.000	8.475	10.638	11.100
4	a'	−8.986	−6.313	−3.640	−2.077	2.567	
	Computed:						
5	$S(w)=$ W_2	125.9	151.6	96.4	116.2	52.7	
6	$S(wx)$	160.7556	159.0749	77.0174	74.6763	12.1587	
7	$\bar{x}$	1.2768515	1.0493067	0.7989357	0.6426532	0.2307154	
8	$S(wy)$	673.863	799.078	524.402	619.182	248.871	
9	$\bar{y}$	5.3523670	5.2709631	5.4398548	5.3285886	4.7224099	
10	$[wx^2]$	0.74431	0.73913	0.69410	0.42131	0.41947	3.01832
11	$[wxy]$	5.92940	11.04518	7.83717	5.14188	4.39044	34.34407
12	b	7.96630	14.94349	11.29113	12.20450	10.46663	11.37854
13	$[wy^2]$	86.30367	181.14501	110.17424	79.90883	50.33984	
14	χ^2	39.0683	16.0915	21.6837	17.1548	4.3867	98.3850
15	n	7	8	5	4	3	27
16	x at $y=5$	1.2459	1.0255	0.7603	0.6138	0.2551	
17	W_2z	0	45.6316	58.0328	90.4036	68.5627	
18	W_2x	156.85881	155.46580	73.29292	71.32356	13.44377	

Determination of Eq. (2) relating x to z:

Graphic:		$S(W_2x)$	470.38486
x at $z=0$	1.260	$\bar{x}$	0.86658965
x at $z=1$	0.460	$[W_2z^2]$	81.13256
b_2	0.800	$[W_2zx]$	63.69543
Computed:		b_2	0.785079
$S(W_2)$	542.8	$[W_2x^2]$	50.16243
$S(W_2z)$	262.6307	a_2	1.24644
$\bar{z}$	0.48384433		

partially corrected by omitting from the series the last seven tests. These showed a marked decrease in sensitivity and included all five lots of beetles exposed for ½ hour and two of those tested for 20 hours.

The data for the remaining 42 observations are given in the first five columns of Table VII. The percentages have been changed to empirical probits (column 6) for plotting as dosage-mortality curves in Fig. 6 and fitted graphically. The values of x interpolated at $y=5$ and 7

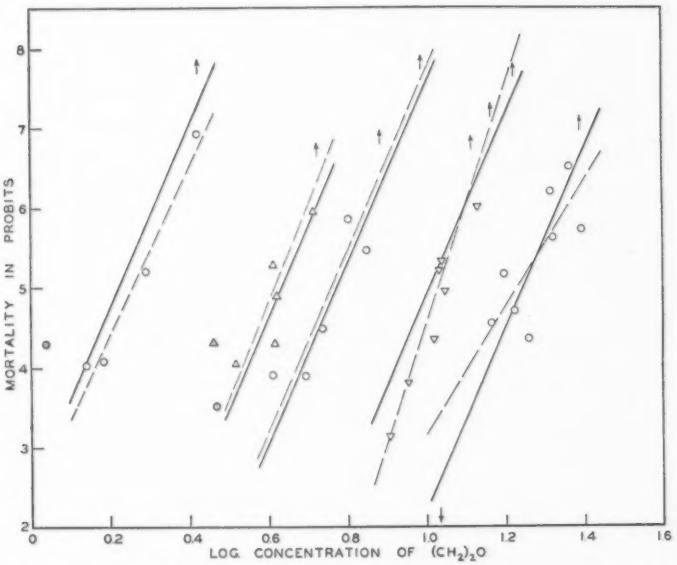


FIG. 6. Dosage-mortality curves measuring the toxicity of ethylene oxide to the grain weevil in terms of probits (y) and log-concentrations (x) for exposures (right to left) of 1, 2, 4, 6 and 20 hours respectively, from data in Table VII as reported by Busvine (9). The broken lines are those computed individually (Table VIII, rows 5–12); the solid lines those expected from the general equation $y = -9.183 + 11.379x + 8.933z$, where z is log-time.

from the five provisional curves have been listed in the first two rows of Table VIII, leading to the provisional slopes in row 3. In the absence of any consistent change in slope with exposure time, they were averaged to obtain the provisional $b_c = 11.100$. Concurrently, x at $y=5$ (row 1) was plotted against z in Fig. 7 (white circles) and fitted graphically with the broken line, from which two points were interpolated for provisional estimates of $a_2 = 1.260$ and $b_2 = 0.800$. Combining these three parameters,

Eq. (23) was solved provisionally as $y=[5-(11.100)\ (1.260)]+11.100x+(11.100)\ (0.800)z=-8.986+11.100x+8.880z$.

The provisional equation relating y to z and x was solved for the five values of z to obtain a' (row 4, Table VIII) for use in computing the expected probit (column 7, Table VII) for each test. In conjunction with the percentage dead the expected probits determined the corrected probits, y, in column 8, and with the number of insects, the corresponding weights, w (column 9). The mortality at the smallest concentration

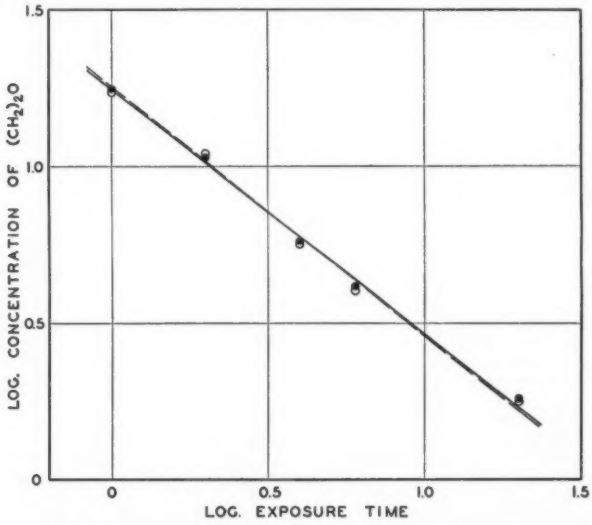


FIG. 7. Toxicity of ethylene oxide to the grain weevil for a mortality of 50 percent; white circles and broken line show the provisional graphic solution, black circles and solid line the computed result from Table VIII, the equation of the latter being $C^{1.27}t=38.7$.

for three of the exposure periods was enough larger than that expected from the remaining tests of the series for the corrected probit to differ by 2.5 probits or more from the empirical value, indicating a change in slope which justified their exclusion. With these omissions, a dosage-mortality curve was computed from x, y and w for each exposure time as shown in the last two columns of Table VII and in rows 5 to 15 of Table VIII, following the standard procedure described elsewhere (5). The χ^2's (row 14) gave clear evidence of the heterogeneity which has been traced in part to a progressive decrease in susceptibility but the distribution of the points plotted in Fig. 6 did not invalidate the use of a linear relation between x and y.

For combining the curves by Eq. (23), the sums of $[wx^2]$ and of $[wxy]$ (rows 10 and 11) gave the combined slope of $b_c = \frac{34.34407}{3.01832} = 11.3785$. With this term x at $y=5$ was computed from $\bar{x}$ and $\bar{y}$ for each z and plotted as the solid circles in Fig. 7. Each x was weighted by $W_2=S(w)$ (row 5) for calculating the corrected $b_2=0.7851$ and $a_2=1.2464$, as shown at the bottom of Table VIII. When combined by Eq. (23), $y=-9.1827+11.3785x+8.9331z$, which agreed closely enough with the provisional estimate that it could be accepted as final for the data in Table VII. Solved for an expected mortality of 99 per cent, $\frac{7.3263+9.1827}{8.9331} = \frac{11.3785}{8,9331}x+z$ or $1.274x+z=1.8481$, but it must be remembered that the reduced susceptibility of the beetles tested at the longest exposure time has partly biased the result.

TABLE IX

STATISTICAL TEST FOR AGREEMENT OF DATA IN TABLE VII WITH EQ. (23) BY THE ANALYSIS OF VARIANCE BASED ON METHOD IN TABLE VI

Variation Due to	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio
(1) Departure from straight line relating x and z in Fig. 7	3	20.2609	6.7536	1.853
(2) Departure from combined slope of individual curves in Fig. 6	4	14.7012	4.6753	1.283
(3) Vertical scatter of plotted points about individual curves in Fig. 6; the experimental error	27	98.3850	3.6439	1

To test whether the data agreed with Eq. (23) within the experimental error, the analysis of variance in Table IX has been computed from the terms in Table VIII by the formulae of Table VI, interchanging x and z. Because of the heterogeneity in the individual curves, their χ^2's were compared by Eq. (25) but the "crude" χ^2 of 1.300 with 4 degrees of freedom showed no difference between them so that a valid estimate of the experimental error could be obtained from their sum.

It was clear from the variance ratios that the individual curves did not differ from parallelism but that the differences between the black circles and the computed straight line in Fig. 7 should be viewed with suspicion even though they were not significant. Although the concave curve of Eq. (18) would fit more closely, it would be futile here to determine C_o because part or all of the apparent curvature may have been due to the order of testing the different periods of exposure. Moreover, with this mode of experimentation, the estimation of C_o would be very laborious

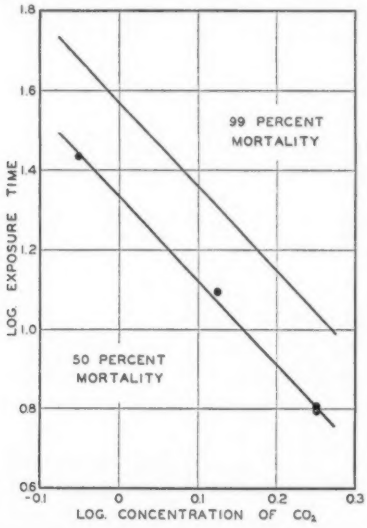


FIG. 8. Toxicity of carbon dioxide to the flour beetle, as reported by Jones (17), showing that in logarithmic units the time-concentration curves are parallel at different mortalities when the constituent dosage-mortality curves are parallel, the equation of both curves being $y = -8.112 + 20.713x + 9.819z$, where y, x and z are probits, log-concentration and log-time respectively.

since the constituent dosage-mortality curves would no longer be parallel and the entire series would have to be computed for each estimate of C_o, a complication which is avoided when the dosage-mortality curves are in terms of y and z instead of y and x.

An experiment on the toxicity of carbon dioxide to *Tribolium confusum* has been reported by R. M. Jones (17), in which he determined the percentage kill for eight or more exposure times in hours at concentrations of 0.89, 1.335 and 1.78 grams per liter, the latter in two separate series. The slopes of the four dosage-mortality curves were 9.88, 8.08,

10.78 and 10.64 respectively, which did not differ significantly from the combined regression coefficient of $b_\epsilon = 9.819$. With b_ϵ the median lethal exposure period (z at $y=5$) was computed for each series and plotted against the log-concentration (x) in Fig. 8. From the straight line fitted to these four points and the combined slope, the mortality in probits (y) expected from any given combination of concentration and exposure time has been computed as $y = -8.112 + 20.713x + 9.819z$.

The variation between the observed mortalities and those expected on the basis of this equation were apportioned to the same three components as before by the analysis of variance in Table X. The four

TABLE X

ANALYSIS OF VARIANCE FOR AGREEMENT WITH EQ. (23) OF DATA REPORTED BY JONES (17) ON THE TOXICITY OF CARBON DIOXIDE TO *Tribolium confusum*

Variation Due to	Degrees of Freedom	Sum of Squares	Mean Square	Variance Ratio
Departure from straight line relating x and z in Fig. 8	2	9.7227	4.8613	3.247
Departure from b_ϵ of component dosage-mortality curves	3	6.8994	2.2998	1.536
Scatter of original observations about component curves	20	29.9425	1.4971	1

points in Fig. 8 were found to vary from the fitted straight line almost at the level of significance, although visually the departures seemed very moderate. The near-discrepancy could not be corrected by computing a threshold concentration, C_o. A likely explanation is that so many beetles were used in determining each curve (from 350 to 450 individuals) that the sampling error of the LD50's had been reduced to a smaller importance than secondary environmental differences and the larger the number of insects the more of these latter there may be. Although the beetles used in the four dosage-mortality curves were from the same culture and tested within a period of a few days, there was probably a greater heterogeneity between curves than between the lots of beetles used in a single series. Because of the frequency with which secondary factors modify the susceptibility of animals to poisons, a given number of insects can be used more efficiently by testing a larger number of concentrations, each with fewer individuals, in a randomized arrangement of concentrations and times than by establishing successively a

smaller number of curves, each based upon more individuals and hence with a smaller sampling error.

RELATION WHEN SLOPE OF THE DOSAGE-MORTALITY CURVE IS A FUNCTION OF THE CONCENTRATION

Not infrequently the relation between concentration, exposure time and mortality is complicated by a systematic increase in the slope of the rectified dosage-mortality curve as the concentration is increased or decreased. This was observed, for example, by Bliss and Broadbent (7) in their study on the toxicity of hydrocyanic acid to Drosophila. Each constituent slope usually has so large an error that several functions would fit its relation to the concentration almost equally well. The simplest of these is to fit a straight line to the reciprocal of the slope plotted against the log-concentration. This is a logical relation, for the reciprocal of the slope is the standard deviation of susceptibility in terms of z. Our basic hypothesis, therefore, is that both of the parameters which define the susceptibility of an insect population to a fumigant at each concentration, the mean (log-LD50) and the standard deviation $(1/b)$, are related to the log-concentration by straight lines.

As in the preceding section, the equation relating concentration, exposure time and mortality can be solved provisionally by graphic methods. Beginning with an experiment in which the percentage kill has been measured at several exposure times for each of three or more concentrations, the mortality in probits (y) is plotted against the log-exposure time (z) for each concentration separately and fitted by inspection with a straight line. One-half of the difference between the z interpolated from each line at $y=5$ and at $y=7$ is a provisional estimate of the standard deviation, s, which, in turn, is plotted against the log-concentration, x. Assuming that the plotted points follow a rectilinear trend, a straight line is fitted graphically which tends to overestimate the observations at its lower end. Its equation can be estimated from two interpolated points and written in the form

$$s_c = a_1 + b_1 x\,, \qquad \ldots\ldots (27)$$

where a_1 and b_1 are the position and slope respectively. The reciprocal of this equation will replace the combined slope, b_c, used in Eq. (23).

The other parameter of each dosage-mortality curve, z at $y=5$, is also plotted against the log-concentration and fitted by inspection with the straight line of Eq. (2) unless a concave curve would be obviously more suitable. In the latter case, a provisional threshold concentration, C_o, can be determined graphically and log $(C-C_o)$ instead of log C designated as x for a revised estimate of Eq. (27) and of Eq. (2). From

two interpolated points provisional values are obtained for Eq. (2) at $y=5$ in the form $z+b_2x-a_2=0$. Combining equations (2) and (27) with the dosage-mortality curve by the same procedure followed in deriving Eq. (23), we have

$$y=5+\frac{z+b_2x-a_2}{a_1+b_1x}, \text{ leading to}$$

$$y=\frac{(5a_1-a_2)+(5b_1+b_2)x+z}{a_1+b_1x}, \qquad \ldots\ldots(28)$$

from which the expected probit mortality can be computed for any combination of x and z within the limits of dosage and effect of the original data.

Although Eq. (28) can be solved graphically as above, the result may be rather wide of the mark unless the plotted points in the basic diagrams fall closely about the lines fitted by inspection. The parameters of an equation have a more delicate mutual balance as their number is increased to four or more, so that discordant observations or a badly placed line in graphic analysis can distort the result more easily. For this reason it is preferable here to compute one stage before proceeding to the next in developing a provisional computed solution from which satisfactory final values can be obtained by a single complete calculation. Without this precaution and in the presence of heterogeneity, successive calculations may converge very slowly indeed.

The recommended procedure parallels the stages described for a graphic approach. The graphic provisional line for the dosage-mortality curve at each concentration is used only in determining the weight for each probit, w, and the corrected probit, y, for any 0 or 100 per cent kills. Each dosage-mortality curve is then computed independently of the others from w, y, the log-exposure times, and the empirical or observed probits for the intermediate mortalities. The reciprocals of the provisionally-computed slopes, $s=1/b$, are then plotted against the corresponding log-concentration and fitted graphically by the straight line of Eq. (27). The values interpolated from this temporary line (s_c) are required in estimating a weight for each computed s, which are seldom of equal value. When the variation about the basic dosage-mortality curves does not vary significantly from one to another, a suitable weight is

$$W_1=\frac{[wz^2]}{s_c^4}, \qquad \ldots\ldots(29)$$

where $[wz^2]$ is the denominator for the slope of each curve and s_c is the

interpolated graphic value noted above. Weighting each observed s by its appropriate W_1, the computation of Eq. (27) parallels that of the dosage-mortality curve. The computed equation not only enters in the initial solution of the general equation (28); it also provides an improved estimate of s_c for each dosage-mortality curve. The latter are used both for computing the median lethal exposure periods from Eq. (22) or z at $y=5$ corresponding to each concentration and for determining the weights

$$W_2 = \frac{S(w)}{s_c^2} = b_c^2 S(w), \qquad \ldots\ldots (30)$$

where $S(w)$ is the sum of the weights for each dosage-mortality curve. Thus W_2 differs here from that given in the preceding section by including b_c^2, which is no longer the same throughout. Eq. (2) is then computed from z and x with the weights W_2 and its parameters are combined with those of Eq. (27) to obtain the general relation between z, x and y given by Eq. (28).

The result so obtained is more reliable than a purely graphic solution but it is preferable to use it as a provisional equation for computing a corrected estimate that can be tested objectively. By solving the provisional equation for appropriate values of x and z, each observed percentage kill can be matched by an expected probit and corrected probits and weights obtained from these for recomputing a linked series of dosage-mortality curves. The provisional equation also provides the s_c occurring in the weight W_1, used in recalculating Eq. (27) from the reciprocals (s) of the redetermined slopes. The remaining stages parallel those in the initial calculation and lead to a corrected estimate of the relation between z, x and y in terms of Eq. (28).

Determination of the time-concentration curve for a specified mortality. The dependence of mortality upon concentration and exposure time can be represented by the three parameters or constants of Eq. (23) when the dosage-mortality curves are parallel and by the four parameters of Eq. (28) when the reciprocal of the slope is a linear function of the log-concentration. For certain purposes these may be reduced to a simpler form applicable to a single specified mortality within the range in which the original equation is valid. The term y is replaced by the required probit kill and by rearrangement Eq. (23) reduces to

$$z + b_2 x = \left(a_2 + \frac{y-5}{b_c} \right)$$

where the original curves are parallel, and Eq. (28) to

$$z + (5b_1 + b_2 - b_1 y)x = a_2 + a_1(y-5)$$

where the slope changes with the concentration in accord with Eq. (27). In the first only the constant k of Eq. (10) varies with the mortality but in the second or whenever the slope is not independent of the concentration, both n and k are subject to change. In using n or b_2 to characterize a poison, therefore, the level of effectiveness should be specified quite as for the constant k or a_2.

Analysis of variance as a test of validity. The suitability of Eq. (28) for any given case depends upon how nearly it duplicates the observed mortalities when solved for all combinations of x and z used experimentally. The same result can be obtained more easily and in a better form by a technique parallel to that in the preceding section. The sums of

TABLE XI

STATISTICAL TEST FOR AGREEMENT WITH EQ. (28); FORMULAE FOR COMPUTING THE SUMS OF SQUARES FOR AN ANALYSIS OF VARIANCE

Departure of	Degrees of Freedom	Sum of Squares
Log-LD50's from straight line of Eq. (2)	$N - 2$	$[W_2z^2]-b_2[W_2xz]$
Individual slopes from values predicted by Eq. (27)	$N - 2$	$S\left\{ b_c^2[wz^2]-(2b_c-b)[wzy] \right\}$
Observations about individual dosage-mortality curves, the error	$S(n)$	$S(\chi^2)$

squares are computed as shown in Table XI, where $b_c = 1/s_c$ or the corrected slope of the dosage-mortality curve computed by Eq. (27) from the log-concentration, b is the slope of the same curve computed directly from the corrected probits and all other symbols have the significance noted previously. If the mean square for error is 1 or less, the significance of the sums of squares in the first two rows may be judged by the χ^2 distribution, but if the mean square for error is greater than 1, it is preferable to test their significance from the variance ratio based upon the mean squares.

Ideally, both the standard deviations (slopes) and the means (log-LD50's) will agree with their respective curves well within the error as computed in Table XI. Departures approaching or exceeding the level of significance, however, do not necessarily invalidate the equation. If inspection shows the discrepancies to be more or less at random and not of a type which could be removed by estimating C_o, the present equation may fit as well as any rational alternative. In view of the

relatively large number of determinations involved in this type of experiment, it is more than ordinarily difficult to insure that all lots of insects have the same susceptibility within the sampling error. The control of this factor probably requires as carefully balanced an experimental design as a modern field experiment. An adverse analysis of variance may be due, therefore, to lack of uniformity in the insect material or in the experimental technique rather than to an inadequacy in the proposed equation.

TABLE XII

EXPERIMENTAL DATA AND CALCULATION OF DOSAGE-MORTALITY CURVES FOR EACH CONCENTRATION OF HYDROCYANIC ACID, IN TERMS OF THE LOG-EXPOSURE TIME AND THE MORTALITY OF *Calandra granaria* IN PROBITS AT 17° C. AS REPORTED BY PETERS AND GANTER (21); 10 BEETLES IN EACH LOT

INITIAL DATA			PROVISIONAL SOLUTION				CORRECTED SOLUTION				
Log-g/m³	Log-Hours	Per-cent Kill	Empir-ical Probit	First Ex-pected Probit			Second Ex-pected Probit	Cor-rected Probit			
x	z		y		w	wz		y	w	wz	wy
1.477	0.176	10	3.72	3.82	3.8	0.6688	4.03	3.77	4.5	0.7920	16.965
	0.301	40	4.75	4.49	5.8	1.7458	4.69	4.75	6.1	1.8361	28.975
	0.477	50	5.00	5.44	5.9	2.8143	5.61	4.92	5.6	2.6712	27.552
	0.544	100	6.53*	5.80	5.0	2.7200	5.96	6.63	4.5	2.4480	29.835
1.380	0.398	60	5.25	5.16	6.3	2.5074	4.69	5.27	6.1	2.4278	32.147
	0.477	70	5.52	5.58	5.6	2.6712	5.14	5.51	6.3	3.0051	34.713
	0.544	80	5.84	5.94	4.6	2.5024	5.52	5.81	5.8	3.1552	33.698
	0.602	90	6.28	6.24	3.6	2.1672	5.85	6.20	4.9	2.9498	30.380
	0.653	100	7.03*	6.52	2.6	1.6978	6.14	6.75	3.9	2.5467	26.325
1.190	0.544	50	5.00	4.97	6.4	3.4816	4.39	5.08	5.6	3.0464	28.448
	0.778	80	5.84	5.99	4.4	3.4232	6.01	5.83	4.4	3.4232	25.652
	0.903	100	7.05*	6.54	2.6	2.3478	6.87	7.31	1.6	1.4448	11.696
1.061	0.699	40	4.75	4.75	6.2	4.3338	4.55	4.76	5.9	4.1241	28.084
	0.778	70	5.52	5.58	5.6	4.3568	5.19	5.51	6.3	4.9014	34.713
	0.845	90	6.28	6.28	3.4	2.8730	5.73	6.16	5.2	4.3940	32.032
	1.000	100	8.23*	7.92	0.2	0.2000	6.98	7.40	1.4	1.4000	10.360
0.929	0.903	0	3.37*	4.04	4.5	4.0635	5.23	3.71	6.2	5.5986	23.002
	0.954	40	4.75	4.70	6.2	5.9148	5.73	4.53	5.2	4.9608	23.556
	1.000	70	5.52	5.30	6.2	6.2000	6.17	5.28	3.8	3.8000	20.064
	1.079	80	5.84	6.32	3.3	3.5607	6.94	4.06	1.4	1.5106	5.684
	1.176	100	7.93*	7.58	0.4	0.4704	7.89	8.20	0.2	0.2352	1.640
0.778	1.204	60	5.25	.....	.....	.....	7.32	−7.17	.....	.....	.....
	1.255	100	.....	.....	.....	.....	7.97	.....	.....	.....	.....
0.544	1.204	20	4.16	4.35	5.5	6.6220	4.01	4.17	4.4	5.2976	18.348
	1.255	80	5.84	5.49	5.8	7.2790	5.27	5.77	6.2	7.7810	35.774
	1.301	90	6.28	6.53	2.6	3.3826	6.42	6.27	3.0	3.9030	18.810
	1.398	100	.....	8.71	0.0	.....	8.57	.....	0.0	.....	.....

*These are corrected probits since the empirical value is indeterminate.

Numerical example. A suitable example is the experiment by Peters and Ganter (21) upon the toxicity of hydrocyanic acid to adult *Calandra granaria* at 17° C. From two to five exposure periods were tested at each of seven concentrations, using 10 beetles for a determination, and

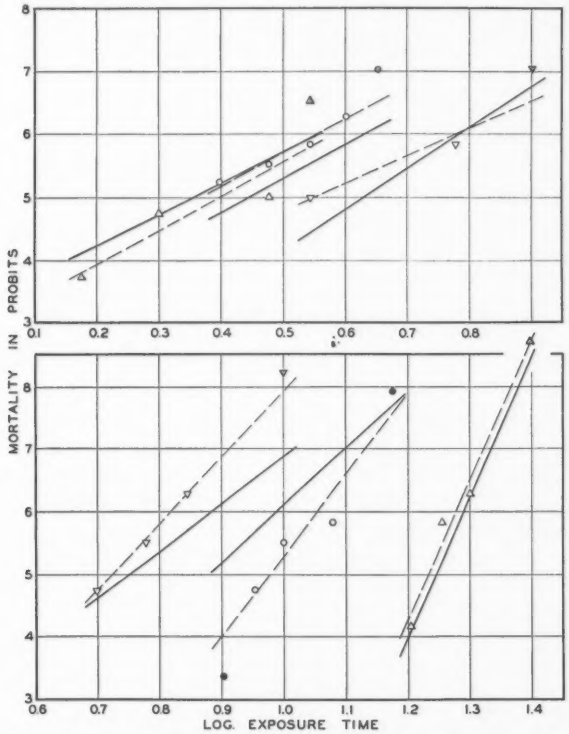


FIG. 9. Dosage-mortality curves measuring at 17° C. the toxicity of hydrocyanic acid to the grain weevil in terms of probits (y) and log-exposure time (z) at six different concentrations, from data in Table XII as reported by Peters and Ganter (21). The broken lines are the individual graphic curves fitted individually, the solid lines those expected from the corrected equation based upon the experiment as a whole; shaded symbols represent 0 and 100 percent mortalities.

in every series all beetles were killed at the longest exposure. The initial data have been listed in the first three columns of Table XII and in the fourth column the percentages have been changed to empirical probits for plotting in Fig. 9. A straight line was fitted by inspection to the observations at each concentration independently (the broken lines in

Fig. 9), except for the isolated observation at $x=0.778$ which has been omitted. The equation for each dosage-mortality curve was determined by interpolation in rows 1–4 of Table XIII.

TABLE XIII

COMPUTATION OF PROVISIONAL DOSAGE-MORTALITY CURVES AND EQ. (28) FROM DATA IN TABLE XII

Row No.	Parameter	Dosage-Mortality Curves for x					
		1.477	1.380	1.190	1.061	0.929	0.544
	Graphic:						
1	z at $y=5$	0.395	0.368	0.550	0.723	0.977	1.233
2	z at $y=7$	0.766	0.744	1.009	0.913	1.131	1.322
3	b	5.391	5.319	4.357	10.526	12.987	22.472
4	a'	2.871	3.043	2.604	—2.610	—7.688	—22.708
	Computed:						
5	$S(w)$	20.5	22.7	13.4	15.4	20.6	13.9
6	$S(wz)$	7.9489	11.5460	9.2526	11.7636	20.2094	17.2836
7	$\bar{z}$	0.3877512	0.5086344	0.6904925	0.7638701	0.9810388	1.2434245
8	$S(wy)$	103.836	131.737	76.026	83.360	101.283	73.080
9	$\bar{y}$	5.0651707	5.8033921	5.6735821	5.4129870	4.9166505	5.2575540
10	$[wz^2]$	0.38310	0.17404	0.28845	0.06074	0.08104	0.01794
11	$[wzy]$	2.35105	1.06247	1.45609	0.64731	1.17550	0.43015
12	b	6.13691	6.10477	5.04799	10.6571	14.5052	23.9770
13	s	0.1629	0.1638	0.1981	0.0938	0.0689	0.0417
14	Graphics	0.1757	0.1617	0.1344	0.1158	0.0968	0.0413
15	W_1	402	255	884	338	923	6166
16	W_1x	593.754	351.900	1051.960	358.618	857.467	3354.304
17	s_c	0.1913	0.1756	0.1448	0.1240	0.1026	0.0403
18	z at $y=5$	0.3753	0.3676	0.5930	0.7127	0.9896	1.2330
19	W_2	560	736	639	1002	1957	8559
20	W_2x	827.120	1015.680	760.410	1063.122	1818.053	4656.096
21	b	5.227	5.695	6.906	8.065	9.747	24.814
22	a'	3.113	2.422	0.633	—1.087	—3.573	—25.867

From the graphic a' and b for each independent curve the first expected probits have been computed (column 5, Table XII) for estimating the corrected probit at 0 and 100 per cent mortalities and for determining the weights (w) for all values. With these terms a provisional dosage-mortality curve was computed for each concentration as shown in rows 5–12 of Table XIII. The parameters of these independent curves had then to be related progressively to the log-concentration x. The first parameter so used was the standard deviation s (row 13), where $s=1/b$ from the preceding row. These were plotted against x as the empty circles in Fig. 10 and fitted graphically with the dotted line, from which the entries in row 14 were obtained. Each was raised to its fourth power and divided into the corresponding $[wz^2]$ of row 10 to obtain the weight $W_1=[wz^2]/s^4$ in row 15. It is evident from the range of W_1 that the estimates of s differed decisively in importance. With W_1, the values of x at the top of each column and s in row 13, b_1 and a_1 of Eq. (27) were computed as shown in the lower left section of Table XIII. The calculation of the other parameter for each dosage-mortality curve, z at $y=5$, drew upon the pooled information in Eq. (27). From b_1 and a_1 a computed s_c (row 17) was determined for each x. Used with the means, $\overline{z}$ and $\overline{y}$ (rows 7 and 9) and Eq. (22) it determined the log-LD50's in row 18 and with $S(w)$ (row 5) their weights W_2 (row 19). The computation of Eq. (2) from z (row 18) and x followed the same stages as before, given in the lower right section of Table XIII.

TABLE XIII—(*Continued*)

Relation of s to x, Eq. (27).

Graphic:	
s at $x=0.5$	0.035
s at $x=1.5$	0.179
b_1	0.144
a_1	−0.037
Computed:	
$S(W_1)$	8968
$S(W_1x)$	6568.003
$\overline{x}$	0.7323821
$S(W_1s)$	634.7956
$\overline{s}$	0.0707846
$[W_1x^2]$	805.963
$[W_1xs]$	130.436
b_1	0.16184
a_1	−0.04774

Relation of z to x, Eq. (2).

$S(W_2)$	13453
$S(W_2x)$	10140.481
$\overline{x}$	0.7537710
$S(W_2z)$	14063.6682
$\overline{z}$	1.0453927
$[W_2x^2]$	1234.442
$[W_2xz]$	1168.281
b_2	0.94640
a_2	1.7588

These complementary equations relating s and z to x were combined to obtain the provisional solution of Eq. (28) as

$$y = \frac{[(5)(-0.04774)-1.7588] + [(5)(0.16184)+0.94640]x+z}{-0.0477+0.1618x} =$$

$$\frac{-1.9975+1.7556x+z}{-0.0477+0.1618x}.$$

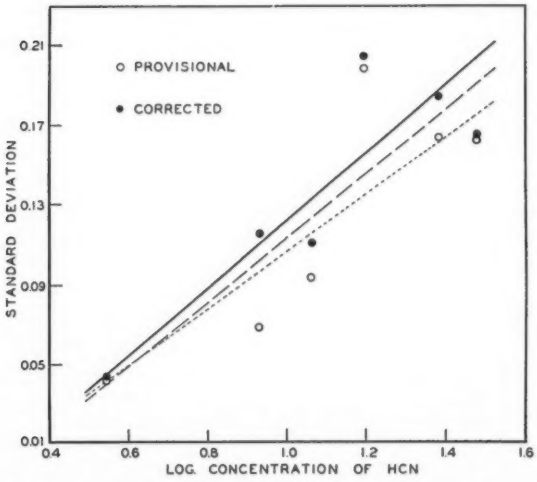


Fig. 10. Relation of the standard deviation (s) or 1/slope to the log-concentration (x) of hydrocyanic acid from Tables XIII and XIV. The graphic dotted line was required in computing the provisional broken line (Table XIII); the equation of the corrected solid line is $s_c = -0.048 + 0.171x$.

For some purposes this may be accurate enough but it is preferable to use it as the starting point for a corrected equation. By solving the provisional equation for successive values of x, b and a' were computed for each basic dosage-mortality curve (rows 21 and 22), from which an expected probit could be calculated for every observed mortality.

The corrected solution of the problem in Table XIV repeated in the main the provisional computation with certain exceptions. Of these the most important was to compute the dosage-mortality curves throughout from corrected probits and redetermined weights, both based upon the second series of expected probits. These values and the

two series of products, wz and wy, which facilitated the computation, constitute the last five columns of Table XII. One corrected probit, that for $x=0.929$ and $z=1.079$, differed by 1.79 units from the empirical value but was retained since the curve as a whole still fell within the sampling error. At $x=0.778$, the expected probit was so much larger than the single empirical value that the corrected -7.17 probits was omitted as clearly discordant with the rest of the experiment. Stages in the calculation of the dosage-mortality curves are given in rows 23–30

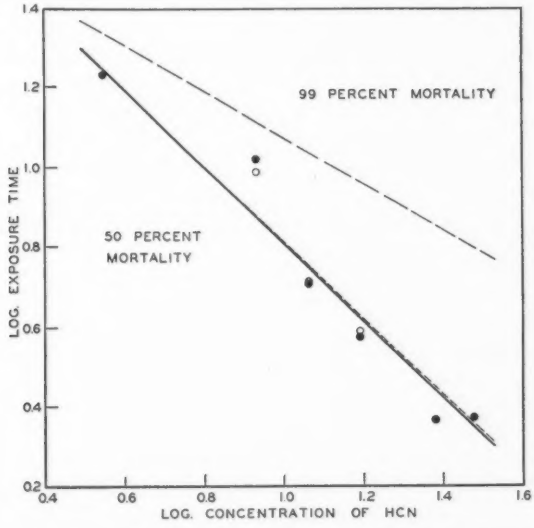


FIG. 11. Toxicity of hydrocyanic acid to the grain weevil based on Tables XIII and XIV, in three of the six determinations the corrected values (solid circles and solid line) coinciding with the provisional estimates (empty circles and lower broken line). Since the original dosage-mortality curves were not parallel, the slope of the time-concentration curve was a function of the mortality.

and of the respective χ^2's in rows 31–33. In recomputing Eq. (27) the dependent variates s (row 34) were the reciprocals of the slopes in row 30 but their weights were based upon those predicted in row 21 from the provisional equation. Except for terms required in the test of significance, the succeeding computation in rows 34 to 43 and at the end of Table XIV followed the earlier pattern. The final individual estimates have been plotted in figs. 10 and 11 as black circles and the equations

TABLE XIV

COMPUTATION OF CORRECTED DOSAGE-MORTALITY CURVES AND EQ. (28) FROM DATA IN TABLES XII AND XIII

Row No.	Parameter	Dosage-Mortality Curves for x					
		1.477	1.380	1.190	1.061	0.929	0.544
23	$S(w)$	20.7	27.0	11.6	18.8	16.8	13.6
24	$S(wz)$	7.7473	14.0846	7.9144	14.8195	16.1052	16.9816
25	$\overline{z}$	0.3742657	0.5216519	0.6822759	0.7882713	0.9586429	1.2486471
26	$S(wy)$	103.327	157.263	65.796	105.189	73.946	72.932
27	$\overline{y}$	4.9916425	5.8245556	5.6720690	5.5951596	4.4015476	5.3626471
28	$[wz^2]$	0.398384	0.207642	0.225341	0.127179	0.055536	0.017243
29	$[wzy]$	2.408107	1.126768	1.103433	1.147002	0.481102	0.392844
30	b	6.04469	5.42649	4.89673	9.01880	8.66288	22.78281
31	$[wy^2]$	19.17975	6.53136	6.36531	10.38035	9.03222	9.75726
32	χ^2	4.6235	0.4170	0.9621	0.0358	4.8645	0.8073
33	n	2	3	1	2	2	1
34	s	0.1654	0.1843	0.2042	0.1109	0.1154	0.0439
35	W_1	297	218	513	538	501	6537
36	W_1x	438.669	300.840	610.470	570.818	465.429	3556.128
37	s_{c2}	0.2039	0.1873	0.1549	0.1328	0.1103	0.0445
38	b_c	24.0531	28.5049	41.6774	56.7024	82.1960	504.9863
39	$2b_c-b$	3.7641	5.2515	8.0149	6.0414	9.4695	22.1610
40	z at $y=5$	0.3760	0.3672	0.5782	0.7092	1.0246	1.2325
41	W_2	498	770	483	1066	1381	6868
42	W_2x	735.546	1062.600	574.770	1131.026	1282.949	3736.192
43	W_2z	187.2480	282.7440	279.2706	756.0072	1414.9726	8464.8100

Relation of s to x, Eq. (27)

$S(W_1)$	8604
$S(W_1x)$	5942.354
$\overline{x}$	0.6906502
$S(W_1s)$	598.5097
$\overline{s}$	0.0695618
$[W_1x^2]$	657.9997
$[W_1xs]$	112.4260
b_1	0.17086
a_1	—0.04844
$5a_1-a_2$	—2.0073
$5b_1-a_2$	1.8102

Relation of z to x, Eq. (2)

$S(W_2)$	11066
$S(W_2x)$	8523.083
$\overline{x}$	0.7702045
$S(W_2z)$	11385.0524
$\overline{z}$	1.0288318
$[W_2x^2]$	1096.616
$[W_2xz]$	1048.245
b_2	0.955891
$[W_2z^2]$	1041.2191
χ^2	39.2115
a_2	1.76506

computed from them as solid lines. Combined by Eq. (28) they gave $y = \frac{-2.0073+1.810x+z}{-0.0484+0.1709x}$. The combination of concentration and exposure time killing 99 per cent of the beetles has been estimated by solving this equation for the corresponding probit of $y=7.3263$, which then reduced to $z+0.574\ x=1.648$ and has been plotted as the upper broken line in fig. 11. The change in slope with the level of response is quite evident.

Agreement between the observed mortalities and those predicted by the above equation has been tested by the analysis of variance (Table XV) based on the equations in Table XI. The first sum of squares was

TABLE XV

ANALYSIS OF VARIANCE FOR AGREEMENT OF EQ. (28) WITH DATA IN TABLE XII

Departure of	Degrees of Freedom	Sum of Squares	Mean Square
Log-LD50's from straight line in Fig. 11.	4	39.2115	9.8029
Standard deviations from straight line in Fig. 10.....	4	1.3599	0.3400
Corrected probits about individual dosage-mortality curves, the error.....	11	11.7102	1.0646

computed in quite the same way as the χ^2 for each constituent dosage-mortality curve as shown in the lower right section of Table XIV. It measured the departure of the log-LD50's from the straight line of Eq. (2). The terms involving b_c have been listed for each concentration in rows 38 and 39 of Table XIV and multiplied in turn by $[wz^2]$ (row 28) and $[wzy]$ (row 29) with due regard for sign. The sum of these products (1.3599) was the second entry in Table XV and measured the departure of the individual observed slopes from those predicted by the equation. The sum of squares for error was the sum of the individual χ^2's in row 32, Table XIV.

Comparison of the mean squares in Table XV showed that the slopes were described with sufficient accuracy by Eq. (27) but that the observed variation about the line relating z and x exceeded the sampling error significantly. Most of this variation could be traced to the observation at $x=0.929$, a discrepancy which could not be corrected by fitting a C_0 greater than zero. In the absence of a better alternative equation, the

discrepancy from the corrected result was attributed to heterogeneity between the lots of beetles used in determining the separate curves for each concentration. In practice such an experiment would be marked "unfinished."

SUMMARY

Not infrequently the dosage in a toxicological research depends upon both the concentration of a poison, such as of a fumigant, and the length of time it acts. Experiments in which one dosage factor is held constant and the other varied over a suitable range yield dosage-mortality curves which can be computed as straight lines in terms of probits and logarithms. In other experiments the exposure time killing "100" or some other percentage of insects may be determined directly for each concentration. Since a three-factor solution of the problem must embrace all combinations of two terms in which the third is held constant, the relation between concentration (C) and exposure time (t) has been examined first for a single level of mortality.

An equation suitable for a large majority of cases is that proposed by Ostwald, $(C-C_o)^n t=k$, where C_o is a threshold concentration and n and k are constants. In the many experiments where C_o seems to equal zero, log t can be plotted against log C as a straight line. The toxicity of the fumigant is directly proportional to the slope of this line (b_2) and inversely proportional to its position (a_2), the numerical values depending upon the mortality involved but the relation holding both for "100 per cent" kills, shown to be a relatively indefinite term, and for lower levels. Equations are given for computing b_2 and a_2 and their standard errors and for testing the significance of any apparent curvature from the computed line. Experiments on the toxicity of hydrogen sulfide to the flour mite and of sodium arsenate to mosquito pupae served as numerical examples.

Concave curvature in the line relating log-time to log-concentration may be assigned to a measurable threshold concentration, C_o, which should be determined. By definition it is the concentration which satisfies the equation, so that log-time plotted against the logarithm of the effective concentration or log $(C-C_o)$ is a straight line. Successive values are assigned to C_o, each leading to a new series of log $(C-C_o)$ against which the log-times (z) can be replotted. The process is continued until the relation between z and log $(C-C_o)$ can be fitted as well by

the linear regression coefficient, b_2, as by a polynomial equation with both a linear and a quadratic coefficient. A method is described for determining this value from three preliminary estimates and for computing the standard errors of the final C_o, b_2 and a_2. An experiment on the toxicity of hydrocyanic acid to the cockroach has been used for illustration.

An extension of the analysis to three factors requires that the mortality be measured at several exposure times for each of three or more concentrations, and a dosage-mortality curve determined for each concentration in terms of probits (y) and log-time (z). Two possibilities are considered. The simpler is that all curves comprising the series are substantially parallel, so that a single combined slope, b_c, can be computed. The other parameter for each curve, the log–LD50 or z at $y=5$, is plotted against the logarithm of the effective concentration (x) and fitted with the straight line $z+b_2x-a_2=0$. Then the general equation for the mortality in probits expected with any given combination of time and concentration is $y=(5-b_ca_2)+(b_cb_2)x+b_cz$. The equation is solved graphically, corrected by computation and its validity tested by an analysis of variance. The procedure has been illustrated by experimental data on the toxicity of ethylene oxide to *Calandra granaria* and of carbon dioxide to *Tribolium confusum*.

The other possibility is that the slope of the dosage-mortality curve changes with the concentration. In this case the two parameters defining the susceptibility of an insect population at each concentration, the standard deviation s or the reciprocal of slope and the mean or z at $y=5$, are plotted separately against the logarithm of the effective concentration. Both diagrams are fitted by straight lines to obtain the two equations $s_c=a_1+b_1x$ and $z+b_2x-a_2=0$ at $y=5$, which are then combined into the single expression

$$y = \frac{(5a_1-a_2)+(5b_1+b_2)x+z}{a_1+b_1x}.$$

Four parameters are required here to compute the mortality expected with different combinations of x and z. The successive stages in computing the equations and an analysis of variance for testing its agreement with the original data are described. An experiment on the toxicity of hydrocyanic acid to *Calandra granaria* served to illustrate the procedure.

Acknowledgments. It is a pleasure to record my indebtedness to Prof. R. A. Fisher for suggesting the method of computing C_o, to Dr. G. Rasch for proposing Eq. (28), to Dr. J. R. Busvine for a transcript of the data used in Table VII, to members of the Institute for Plant Protection in Rostov-on-Don, USSR, for data in Table II and to Dr. R. M. Jones for notes on the experiment shown in Fig. 8. This paper is based upon a report written by the author in August, 1937, at the Institute for Plant Protection, Leningrad, USSR.

REFERENCES

(1) **Allison, J. B.** 1928. Studies on the toxicity of hydrocyanic acid. Ia. State Col. Jour. Sci. 2(4): 243–252.
(2) **Bartlett, M. S.** 1937. Some examples of statistical methods of research in agriculture and applied biology. Suppl. Jour. Roy. Stat. Soc. 4(2): 137–183.
(3) **Bliss, C. I.** 1935. The calculation of the dosage-mortality curve. Ann. Appl. Biol. 22(1): 134–167.
(4) **Bliss, C. I.** 1937. The calculation of the time-mortality curve. Ann. Appl. Biol. 24(4): 815–852.
(5) **Bliss, C. I.** 1938. The determination of the dosage-mortality curve from small numbers. Quart. Jour. Pharm. Pharmacol. 11(2): 192–216.
(6) **Bliss, C. I.** 1939. The toxicity of poisons applied jointly. Ann. Appl. Biol. 26(3): 585–615.
(7) **Bliss, C. I.,** and **Broadbent, B. M.** 1935. A comparison of criteria of susceptibility in the response of Drosophila to hydrocyanic acid gas: I. Stupefaction time and mortality. Jour. Ec. Ent. 28(6): 989–1001.
(8) **Bliss, C. I.,** and **Marks, H. P.** 1939. The biological assay of insulin. II. The estimation of drug potency from a graded response. Quart. Jour. Pharm. Pharmacol. 12(2): 182–205.
(9) **Busvine, J. R.** 1938. The toxicity of ethylene oxide to *Calandra oryzae, C. granaria, Tribolium castaneum* and *Cimex lectularius.* Ann. Appl. Biol. 25(3): 605–632.
(10) **Carpenter, E. L.,** and **Moore, W.** 1938. Sorption of hydrocyanic acid by different species of insects. Jour. Ec. Ent. 31(2): 270–275.
(11) **Clark, A. J.** 1937. General Pharmacology. Handb. exper. Pharmak. 4: 1–228. Julius Springer, Berlin.
(12) **Fisher, R. A.,** and **Yates, F.** 1938. Statistical Tables for Biological, Agricultural and Medical Research, pp. 1–90. Oliver and Boyd, London.
(13) **Gause, G. F.** 1933. Certain properties of the curves of toxicity. Protoplasma 17(4): 548–553.
(14) **Gough, H. C.** 1939. Factors affecting the resistance of the flour beetle, *Tribolium confusum* Duv., to hydrogen cyanide. Ann. Appl. Biol. 26(3): 533–571.
(15) **Hoskins, W. M.** 1932. Toxicity and permeability. I. The toxicity of acid and basic solutions of sodium arsenite to mosquito pupae. Jour. Ec. Ent. 25(6): 1212–1224.
(16) **Irwin, J. O.** 1937. Statistical method applied to biological assays. Suppl. Jour. Roy. Stat. Soc. 4(1): 1–60.
(17) **Jones, R. M.** 1935. The toxicity of carbon dioxide-methyl formate mixtures to the confused flour beetle (*Tribolium confusum* Duv.). Jour. Ec. Ent. 28(2): 475–485.
(18) **Moore, W.** 1936. Differences between resistant and non-resistant red scale in California. Jour. Ec. Ent. 29(1): 65–78.
(19) **Ostwald, W.,** and **Dernoschek, A.** 1910. Über die Beziehungen zwischen Adsorption und Giftigkeit. Kolloid-Zeitschr. 6(6): 297–307.
(20) **Peters, G.** 1936. Chemie und Toxikologie der Schädlingsbekämpfung. Samml. chem. chem.-techn. Vorträge, Heft 31: 1–120. Ferd. Enke, Stuttgart.
(21) **Peters, G.,** and **Ganter, W.** 1935. Sur Frage der Abtötung des Kornkäfers mit Blausäure. Zeitschr. f. Angew. Entom. 21(4): 547–559.
(22) **Snedecor, G. W.** 1937. Statistical Methods. pp. 1–341. Collegiate Press, Ames, Ia.

BOOK NOTICES

LIVING LIGHT, by E. NEWTON HARVEY. Pages xv and 328. Colored frontispiece and 79 text figures; 9¼ x 6¼ inches. 1940. Published by the PRINCETON UNIVERSITY PRESS, Princeton, N. J. For sale also by the OXFORD UNIVERSITY PRESS. Cloth, $4.00.

This large well illustrated volume is the summary of twenty-five years' work by Professor Harvey of Princeton University on light production by luminescent organisms. Such a study has some of the fascination of the hunt for the philosopher's stone the touch of which could cure all ills or even transmute base metals into gold. Light without heat is theoretically a valid goal in research, but to the average match scratcher is almost in the same category as perpetual motion. Nevertheless, many organisms do produce light by luminescence in quantity with the accompaniment of a very minute amount of heat as compared with the heat evolved when light is ordinarily produced by incandescence. It can be shown that the heat produced by the light producing reaction in some animals is less than that evoked by stirring and mixing the necessary solutions in reproducing the luminescent reaction. Thus animals produce the very desirable "cold light."

We find a further type of light in the organic and also in the inorganic world, that of phosphorescence, where materials can absorb light and can later give off light in the dark, in fact they give off this ghostly light from the first impact of the exciting agent but it is not visible until darkness supervenes. Many luminous paints are compounded on this principle.

The present volume is devoted to luminescence or light evolved by organisms. The following series of chapter headings indicate the author's analysis of the subject matter: I. Cold Light; II. Light-producing Organisms; III. Types of Luminescence; IV. Chemistry of Light Production; V. Physiology of Light Production; VI. Physical Nature of Animal Light; Bibliography; Index.

Chapter IV, pages 122–159, The Chemistry of Light Production, treats of, Luminescence and water, Luminescence and oxygen, Production of carbon dioxide, Photogen, Luciferin and luciferase, Photophelein, Specificity of photogenic substances, Properties of photogenic substances, Proluciferin, Oxidized luciferin, Luciferesceine, Models of bioluminescence, Kinetics of luminescence, Mechanism of luminescence and the Evolution of living light.

To a zoologist the most interesting part of the work is chapter two on light producing organisms. About half of the excellent illustrations apply to this chapter. Figure 1 is the face of a man with Rooseveltian teeth, a photograph taken under the flourescent light excited by ultra-violet rays. His rows of teeth and pearl buttons shine like spotlights. Many of the illustrations are of luminescent animals, bacteria, fungi, etc., on black backgrounds, photographs taken by the organism's own light. Here we see the many marine forms that luminesce. The reader will remember Beebe's experiences in the bathysphere at sea-depths of over a thousand feet where he entered a world of animal life in which each fish or arthropod carried luminous organs that lit his way through an otherwise complete black-out. These mysteries still appeal to us and fascinate. It is of such known to the average reader only by his visions of dancing fire-flies or an occasional stump lit up with "fox-fire" that Professor Harvey writes. To the student of physics and the engineer in the production of better illumination it is the biologist's contribution to an ultimate knowledge of cold light. Such light is desirable because it is without heat that now accounts for the greater per cent of the monthly light bill. This heat is that which burns out lighting apparatus and takes expensive coal or water power to produce to do benefit to man. Because of the necessity of a better and cheaper illumination for nocturnal man it would appear that very much more research could be applied to a study of such light produced by animals.

The volume is an interesting book on a present by-path in biology but one which should be more of a highway. The volume is large and packed with pertinent material from cover to cover. It is a very great credit to both the author and his university. In closing we might point out that in the twenty-five years of work on this subject Professor Harvey has covered the world for

luminescent life. He has studied at biological stations from Maine and Puget Sound to La Jolla and the Tortugas. He has done research in Naples, Plymouth, Bermuda, the Philippines, in Java and in the little known Banda Islands of the Dutch East Indies. He has made three trips to Japan and was once reported to have been eaten by the cannibals of New Guinea.—C. H. K.

THE FRANCIS WALKER TYPES OF TRICHOPTERA IN THE BRITISH MUSEUM, by CORNELIUS BETTEN AND MARTIN E. MOSELY. Pages ix and 248, 132 text figs. and portrait of Walker. 10 x 7½ inches, 1940. Published by Order of the TRUSTEES OF THE BRITISH MUSEUM (of NATURAL HISTORY), London, S. W. 7. Price, cloth bound, fifteen shillings ($3.50).

To a person who has collided with various problems in taxonomy, more often for a fall than a win, this book brings a glow of pride: pride in those men in his profession who have that outstanding ability which sees basic problems vividly enough to compel them to clean up problems left by others that the science itself be sound rather than that their names will be printed and reprinted as authors of species two hundred years hence. (We feel strongly in this matter as in moments of weakness we publish "new species" ourselves.) The present work clears the way basically for sound work on North American Trichoptera. It is written by two of the recognized experts in the field. Dean Betten, of Cornell University, wrote the only general volume we have on North American Trichoptera while Mr. Mosely, of the British Museum, has published the latest authoritative work on British Trichoptera.

The taxonomy of the Trichoptera has been in a bad condition as far as those species are concerned which were collected in the early days (before 1875) and which were deposited in the British Museum and described by that institution's cataloguer of insects, Francis Walker. In the sixty-eight volumes on insects by Francis Walker published by the British Museum between 1844 and 1873 about 50,000 species of insects were listed. Several thousand were described as new. All principal orders were treated wholly or in part except the Coleoptera. The curators of the Museum demanded catalogues and got them but they were compiled without the basic scientific study necessary in groups such as Trichoptera where relationship cannot be established on evanescent colors and similar characters chosen in a hastily written description.

The present volume redescribes all the Walker types in this order, with elegant drawings by Mr. D. E. Kimmins of the British Museum, another expert on European Trichoptera, and with critical help, loan of material for comparison, etc., by the American experts, Dr. Nathan Banks, Dr. H. H. Ross and D. G. Denning. The great continental expert on the group, Dr. Georg Ulmer, has also assisted.

In the Trichoptera modern descriptions of species are based on male genitalia with ample drawings of the intricacies of such. (Only those with positive ability as draughtsmen should describe species in the group.) The present volume with its numerous figures of genitalia and also of venation is based squarely on our present-day concepts of such adequate description.

The work is in two parts, pages 1–184, North American Species, and pages 185–243, Species Other Than North American. Elaborate synonymies are given under each species heading which correctly tie the present work into the published literature.—C. H. K.

STUDIES IN THE GENETICS OF DROSOPHILA, directed by J. T. PATTERSON. The University of Texas Publication No. 4032.

The publication consists of twelve papers, of which all but the last two are concerned with problems of aneuploidy and chromosomal aberrations. They represent a contribution to a line of investigation which has been carried on at the University of Texas for the past eight years as a basis for studies in the general problem of speciation. Considerable information is presented on chiasma formation, disjunction, crossing over, and segregation in relation to chromosomal aberrations.

The duplicationintersex method was used to ascertain whether a primary female sex gene is present in the X-chromosome of *D. melanogaster*, using transloca-

tions which were not available at the time when earlier similar studies were made. No marked shift in the female direction was noted in any of eight duplication-intersexes covering successively in triplicate the entire X-chromosome. This shows that there is no primary sex gene which when present three times with three sets of autosomes can produce a functional female.

The chromosome number of *D. melanogaster* has been both increased and decreased by the use of certain translocations. Part of the X-chromosome may become autosomal, and part of an autosome may become X-chromatin. X-chromatin derived from an autosome is then present singly in males and in duplicate in females, while X-chromatin incorporated in an autosome is present twice in each sex.

Homozygous duplications (tetraploid regions) decrease fertility and viability more than do the corresponding heterozygous duplications, and these in turn usually more than normal. The effect of a homozygous duplication is not proportional to its length.

A translocation between the X-chromosome and the left end of the fourth chromosome in *D. melanogaster* pulls this part of the chromosome out of the chromocenter so that its morphology may be more easily studied. Once its morphology is known it can be detected in a number of normal preparations, confirming its existence. Thus chromosome four is in reality a J.

The last two papers deal with the problem of speciation. The clearest and simplest case thus far reported in the origin of variation in *Drosophila* is in *D. virilis*. There are three subspecies, *D. v. virilis*, *D. v. texana*, and *D. v. americana*. All differ in their metaphase figures. *Virilis* has five pairs of rods and a pair of dots, *texana* has a pair of V's which is equivalent to two pairs of rods, while in *americana* the X is attached to one of the rod-shaped autosomes and there is also a pair of V's. The autosomal V's of these two subspecies have one rod in common. Various simple and complex inversions have produced differences between some of the chromosomes, while others are apparently identical. There are several deterrents to hybridization, such as sexual preference of individuals for those of the same subspecies, reduced egg hatch due to aneuploid gametes produced by hybrids, and a complex Y-autosome relationship necessary for fertility in certain crosses. In contrast to this the metaphase figures of three subspecies of the *mulleri* group are practically indistinguishable. The results of crosses among them are compared with the *pseudoobscura-miranda* crosses and with *melanogaster-simulans* relationships.—B. DAVIDHEISER.

PLANT GALLS AND GALL MAKERS, by EPHRIAM PORTER FELT. Pages viii and 364, 344 text figs. and 41 pls. 6 x 9 inches. Published by the COMSTOCK PUBLISHING COMPANY, INC., Cornell Heights, Ithaca, N. Y. Price, linen bound, $4.00.

Plant Galls and Gall Makers is a summary of our knowledge of the plant galls and the various Arthropods (mainly insects) which produce them. The area covered is the continental United States with references scattered through the text to species from Mexico and from other North American areas. Because of Dr. Felt's long association with work in southeastern New York and Connecticut that area is probably most thoroughly covered. In a life time devoted to entomology he has employed the study of gall insects more or less as a hobby and has contributed greatly to a knowledge among teachers and entomologists generally of galls by his earlier volume, "Key to Gall Midges" (N. Y. State Mus. Bull. No. 257, pp. 1–239, pls. 1–8 and 57 figures, 1925). The longer bibliography of articles and works on the subject by Felt and others is given in Bulletin 257. Such works to be of real value depend largely on good illustrations. It takes years to accumulate the photographs and drawings such as appear in the two volumes.

The book is divided into two parts: Part I. "Introduction," is a review of the life histories involved, the types of galls, how galls are produced, alternation of generations, distribution, etc. Part II. "Key to the Galls of the Various Plant Families," pp. 39–338, is the main body of the work. To use the volume with certainty one has to have a smattering of what our botany department labels "Local Flora." The text is a series of keys, each to the galls of a family or a

small group of related families of plants. The index is a list of plant families. Thus a particular gall may key out in more than one place.

In browsing through the volume we have learned a number of interesting facts that we had not run across before. Cactus plants have galls. There are gall insect larvae which do not feed on the host plant tissue directly but on ambrosia fungus the spores of which are inserted by the mother insect when she oviposits. In these the larva develops little until the supply of ambrosia has grown. Probably the oaks are more subject to galls than any other group of plants. Seven hundred and eighty species, mostly Cynipidae, attack them. Some oak galls are 65% tannic acid. Other oak galls are quite edible and are used as food by birds and even domestic animals. One such in Missouri is known as "black oak wheat." Honeydew producing galls support large ant populations and in parts of California bees may make as much as thirty to forty pounds of honey per hive from oak gall honeydew.

After attempting to write a few short keys to dragonflies we wonder at the author's ability to write two hundred pages of keys. It is an ability beyond anything the reviewer possesses in ability along these lines.

The present work will be one of the very useful works in any nature-lover's library. Our personal experience with the earlier volume is that the user could locate his collection of galls precisely and rapidly—perhaps until one comes to the less differentiated types which are difficult in any language.

The press work is excellent, the paper very white and opaque, the binding attractive and sturdy. Above all the book lies flat open on the laboratory table.

—C. H. K.

AN INTRODUCTION TO ENTOMOLOGY, by J. H. Comstock. Ninth Edition, pp. xix and 1064, 1228 text figs., 1940, 9½ x 6½ inches. Published by the Comstock Publishing Company, Ithaca, N. Y. Price, cloth bound, $5.00.

This textbook has enjoyed well deserved popularity for 20 years. A new edition reminds us of the passage of time but impresses us anew with the fundamental thoroughness of this text in which revision necessitates such relatively small changes. Part I, "The Structure and Metamorphosis of Insects," is unchanged. Part II, "The Classification and the Life Histories of Insects," shows slight though important revisions in the Chapter on Hymenoptera (XXX), here more complete knowledge of habits and taxonomy has shown different relationships for certain families of the Chalastogastra and Clistogastra. New keys to these suborders have been added and the discussion of the Ichneumonoidea and the Chalcidoidea has been revised and expanded a total of 17 pages. There are no new figures or plates.

The workmanship displayed in the book is excellent save for a few minor blemishes, such as slight errors in page and figure references. The book is well bound as such a text must be to withstand the constant hard usage which it will surely get.—P. E. Sch.

A GOLDEN ANNIVERSARY, 1890–1940, THE WAVERLY PRESS, Baltimore. Pages 1–16, 5 pls., 8.5 x 11 inches. A gift book published by The Waverly Press, Mount Royal and Guilford Avenues, Baltimore, Md.

This lovely gift volume is in memory of the fiftieth year of the operation of the Waverly Press. The Annals of the Entomological Society of America wishes to congratulate the management of the Waverly Press on the extent and distinction of their contributions, by way of the highest grade of press work, to science in America. The Press' motto, "Sans Tache," has been adhered to through depressions as well as in periods of business prosperity until the printing trade looks to the Waverly Press for the latest and best in the printing of scientific books and journals. Their plant is thought of as being the last word in mechanical excellence, their loyal staff as a group of technical experts down to the youngest printer's devil. From them the Annals has had many favors in scientific volumes for review and, most valuable of all, checks on publication costs.—C. H. K.

THE MEMBRACIDAE OF OHIO, by HERBERT OSBORN. 51 pages, 31 figs., 9¾ x 6¾ inches, 1940. Bull. 37, OHIO BIOLOGICAL SURVEY, Ohio State University, Columbus, Ohio. Paper bound, price $0.75.

This review of the species of tree hoppers found in Ohio will be a very convenient manual for students of the group in days to come. The Membracidae form a small but interesting family. Professor Osborn has had them as one of his numerous minor interests for a good many years. The present bulletin is the result of years of data collected by himself and various of his students. It is well supplied with keys which, with the good illustrations and descriptions, make it very useful.

Professor Osborn's productivity continues to thrill us but he enjoys it.

—C. H. K.

JOHN AND WILLIAM BARTRAM, by ERNEST EARNEST. Pages vi and 187, 2 portraits; 5½ x 8¼ inches, 1940. Published by the UNIVERSITY OF PENNSYLVANIA PRESS (in England, the OXFORD UNIVERSITY PRESS). Price, linen bound, $2.00.

As a youth interested in Indian mounds, relics and Indians in general, one of our unappeased youthful desires was a copy of "Bartram's Travels," published in 1791. During the time of our great desire copies could be had from dealers in second-hand books at the then very great price of $20.00 (but now advanced, when obtainable, to over $100.00). These prices and the fact that it was republished in England, Ireland, Holland, France and Germany, show at once the great value placed on this volume. In fact, two editions have appeared since 1928. For years it was a major source book for poets and other writers who wished authentic information on the life of the American Indian. Today it is our soundest and most detailed account of the Indians of the southeastern United States before aboriginal life was changed by European civilization (?). William Bartram, author of the "Travels," was the son of John Bartram, who was even more widely known and more highly respected as a collector and botanist. Linnaeus wrote of John the father as "the greatest natural botanist in the world." Both father and son published various "journals" of trips into the then wilder parts of the colonies and Florida.

The two Bartrams lived in a period when many gentlemen in England and France were much interested in procuring new flowers, fruits and trees from America. Botanic gardens were a fad for almost a century. While John Bartram made his living more or less as a farmer he established a private botanic garden in the environs of Philadelphia which at the time was one of the very famous gardens of the world. It became a nursery for the many new plants he discovered in the colonies. Here stocks were multiplied and from here shipments were sent to the more formal gardens of the old world. Many exploring trips by both father and son were made at the expense of wealthy collectors of rare plants in Europe.

The present volume is not a biography of a very important father and son but a series of very readable chapters on the connections of these men with other scientists in this country and abroad, chapters on their activities in the development of Philadelphia as America's first scientific center, chapters on the influence of their writings on that European prose and poetry which touched on American life and particularly the beauties of nature and the more romantic aspects of the life of the unspoiled American Indian.

It is the best picture of which we know of the early scientific life during that period covered by the life of Benjamin Franklin.

We recommend this volume as a delightful Christmas remembrance to anyone interested in the beginnings of biological science in America.

This is one of a series of biographic volumes on famous Pennsylvanians which is being developed by the University of Pennsylvania Press.—C. H. K.

CORRECTIONS (ERRORS AND OMISSIONS)

Beginning with Volume 28 (1935), the Annals of the Entomological Society of America has been accepting corrections (omissions and errors) of articles which have appeared in its pages. These are collected and printed at the end of the annual volume (December issue). They are indicated in the annual table of contents and in the index.

Corrections will be limited to critical omissions and serious errors. Manuscript for such should be in the hands of the Editors by the twentieth of November to be included in that year's volume.

The Editors.

These will appear in the March, 1941, Issue.

INDEX TO VOLUME XXXIII

Abercrombie, Warren Fulton (with Ludwig), Article by, 385.
Acanthoscelides obtectus, Longevity and Egg Production in the Common Bean Weevil, 361.
Acerentomidae, 534.
Acerentomon, 535.
  americanum, 536.
  andrei, 537.
  christensoni, 537.
  conurus, 541.
  occidentalis, 540.
Acerentulus, 542.
  aureitarsus, 544.
  barberi, 549.
  bicolor, 543.
  californicus, 550.
  floridanus, 546.
  oculatus, 545.
  tristani, 548.
Agrilus, 556.
  catalinae, 556.
Alexander, Charles P., Article by, 140.
Alysia ridibunda Say, Into Uvalde County, Texas, The Introduction of the Indigenous Blowfly Parasite, 103.
Amobia, 594.
  floridensis, 594.
Anicistrocerus, 593.
  tuberculocephalus, 593.
Anisembia, 649.
  davisi, 656.
  heymonsi, 658.
  rubra, 659.
  schwarzi, 652.
  sini, 654.
  texana, 650.
  wheeleri, 657.
Anisembiidae, 642, 681.
Anisembiinae, 649.
Anopheles maculipennis Complex, The Nomenclature and Taxonomic Status of the Mosquitoes of the, 343.
Anopheles, 353.
  atroparvus, 354.
  labranchiae, 354.
  maculipennis, 353.
  melanoon, 353.
  messeae, 353.
  occidentalis, 354.
  sacharovi, 354.
  subalpinus, 354.
Anthrax, 595.
  fur, 595.
Apanteles, 231.
  congregatus, 231.
Apechthis, 310.
  annulicornis, 312.
  ontario, 310.
  picticornis, 313.
Aphis, 404.
  brassicae, 404.
Atholus, 8.
  minutus, 8.

Baëtis, 332.
  angulata, 332.
  annulata, 332.
  basalis, 332.
  canadensis, 333.
  debilis, 333.
  fusca, 334.
  fuscata, 334.
  invaria, 335.
  tesselata, 336.
  vicaria, 336.
Bates, Marston, Article by, 343.
Bequaert, J., Article by, 95.
Bliss, C. I., Article by, 721.
Blowfly Parasite, Alysia ridibunda Say, Into Uvalde County, Texas, The Introduction of an Indigenous, 103.
Bohart, Richard M., Articles by, 162, 282.

Book Notices:

Barrows, E. Fletcher. Pedigrees and Checkerboards, 577.
Baily, Joshua L., Jr. Physiological Group Differentiation in *Lymnaea columella*, 229.
Balduf, Walter Valentine. The Bionomics of Entomophagous Insects, 483.
Banta, A. M. (with Wood, Brown and Ingle). Studies on the physiology, Genetics and Evolution of Some Cladocera, 228.
Beadle, G. W. (with Sturtevant). An introduction to Genetics, 55.
Betten, Cornelius (with Mosely). The Francis Walker Types of Trichoptera in the British Museum, 768.
Bingham, Marjorie T. Orchids of Michigan, 700.
Blackwelder, Richard E. Fourth Supplement to the Leng Catalogue of Coleoptera of America, 227.
Bradley, James Chester. Guide to the Study of the Evolution of the Wings of Insects, 226.
Brown, L. A. (with Banta, Wood and Ingle). Studies on the Physiology, Genetics and Evolution of Some Cladocera, 228.
Bueno, J. R. de la Torre. A Synopsis of the Hemiptera-Heteroptera of America North of Mexico, 34.
Burks, B. D. Revision of the Chalcidflies of the Tribe Chalcidini in America, North of Mexico, 551.

Book Notices—(*Continued*).

Castle, William E. Mammalian Genetics, 598.
Caullery, Maurice. Les Progrès Récents de l'Embryologie Experimentale, 486.
Chamberlin, Ralph V. (with Ivie). Agelenid Spiders of the Genus Cicurina, 554.
Chamberlin, W. J. The Bark and Timber Beetles of North America, North of Mexico, 227.
Clark, Andrew G. (with Leonard). Field Plot Technique, 596.
Clausen, Curtis P. Entomophagous Insects, 720.
Comstock, John H. The Spider Book, 481.
Comstock, J. H. An Introduction to Entomology, 770.
Cutright, Paul Russell. The Great Naturalists Explore South America, 478.
Dalcq, Albert M. Form and Causality in Early Development, 484.
Dickinson, James G. Outline of Diseases of Cereal and Forage Crop Plants of the Northern Part of the United States, 228.
Eales, N. B. The Littoral Fauna of Great Britain, 394.
Earnest, Ernest. John and William Bartram, 771.
Edwards, F. W. (with Oldroyd and Smart). British Blood-sucking Flies, 628.
Emans, Elaine V. About Spiders, Introducing Arachne, 598.
Felt, Ephriam Porter. Plant Galls and Gall Makers, 769.
Francon, Julien. The Mind of the Bees, 268.
Fox, Irving. Fleas of Eastern United States, 32.
Gill, Robert S. The Author Publisher Printer Complex, 596.
Guise, C. H. (with Gustafson, Ries, Hamilton). Conservation in the United States, 225.
Gustafson, A. F. (with Ries, Guise, Hamilton). Conservation in the United States, 225.
Hamilton, W. J. (with Gustafson, Ries, Guise). Conservation in the United States, 225.
Harvey, E. Newton. Living Light, 767.
Holmes, Francis O. Handbook of Phytopathogenic Viruses, 226.
Ingle, Lester (with Banta, Wood and Brown). Studies on the Physiology, Genetics and Evolution of Some Cladocera, 228.
Ivey, Wilton (with Chamberlin). Agelenid Spiders of the Genus Cicurina, 554.
Jenkins, Thomas N. (with Warden and Warner). Comparative Psychology, 597.
La Gorce, John Oliver (Editor). The Book of Fishes, 323.
Lengerken, H. V. Die Brutfürsorge—und Brutpflegeinstinkte der Kafer, 485.
Leonard, Warren G. (with Clark). Field Plot Technique, 596.
Marshall, J. F. The British Mosquitoes, 229.
Mosely, Martin E. (with Betten). The Francis Walker Types of Trichoptera in the British Museum, 768.
Moulton, F. R. (Editor). Problems of Lake Biology, 482.
Neave, Sheffield Airey (Editor). Nomenclator Zoologicus, 80.
Needham, Paul R. Trout Streams, 559.
Oldroyd, H. (with Edwards and Smart). British Blood-sucking Flies, 628.
Osborn, Herbert. The Membracidae of Ohio, 771.
Parey, Paul (Publisher). Handbuch der Pflanzenkrankheiten, 403.
Paterson, D. D. Statistical Technique in Agricultural Research, 112.
Patterson, J. T. Studies in the Genetics of Drosophila, 768.
Revista del Instituto de Salubridad y Enfermedades Tropicales. A New American Biological Journal, 481.
Ries, H. (with Gustafson, Guise, Hamilton). Conservation in the United States, 225.
Scheinfeld, Amaram (with Schweitzer). You and Heredity, 480.
Schmidt, Gunther. Gebräuchliche Namen von Schadinsekten in Verschiedenen Ländern, 102.
Schweitzer, Morton D. (with Scheinfeld). You and Heredity, 480.
Shepard, Harold H. The Chemistry and Toxicology of Insecticides, 479.
Smart, J. (with Edwards and Oldroyd). British Blood-sucking Flies, 628.
Snyder, Laurence H. The Principles of Heredity, 356.
Sturtevant, A. H. (with Beadle). An Introduction to Genetics, 55.
Treloar, Alan E. Elements of Statistical Reasoning, 119.
Van Leeuwenhoeck, Antoni, The Collected Letters of. Edited by a committee of Dutch Scientists, 484.
Von Weiss, Hubertus A. Beiträge zur Biologie und Bekämpfung Wichtiger Öleruchtschädlinge, 479.
Warden, Carl J. (with Jenkins and Warner). Comparative Psychology, 597.

Book Notices—(*Continued*).
Warner, Lucien H. (with Warden and Jenkins). Comparative Psychology, 597.
Wasmann Collector, The. A recently established journal, 384.
Waverly Press, The. A Golden Anniversary, 770.
Whitehouse, Francis Cecil. Canadian and Other Poems, 230.
Wood, Thelma R. (with Banta, Brown and Ingle). Studies on the Physiology, Genetics and Evolution of Some Cladocera, 228.

Boughton, Donald C. (with Bushnell), Article by, 361.
Brachmeria, 594.
  mexicana, 594.
Brevicoryne van der Goot, Three Aphids of the Genus, 404.
Brevicoryne, 404.
  brassicae, 404.
  salixutis, 405.
  symphoricarpi, 405.
Bulbocerca, 654.
Burmeister Types, Arkansas, Cyclocephalini with Notes on, 377.
Bushnell, Ralph J. (with Boughton), Article by, 361.

Caenis, 337.
  diminuta, 337.
Catachlorops, 689.
  transposita, 690.
Ceuthophilus, 19.
Chalybion, 591.
  zimmermanni, 591.
Chelicerca, 656.
Chlorocypha, A New Species of, 552.
Chlorocypha, 552.
  armageddoni, 552.
Chrysis, 593.
  mucronatus, 593.
Clothodidae, 678.
Coleoptera, Four New Species of Western, 555.
Compsomyiops wheeleri (Hough) and Description of the Larva, The Biology of, 578.
Cora, 430.
  confusa, 430.
Corrections and Errors, 772.
Crane-flies of Mexico, Studies on the, 140.
Cricket-locust (Typhloceuthophilus floridanus n. gen. et sp.) Inhabiting Geomys Burrows in Peninsular Florida, A Blind, 10.
Cyclocephala, 379.
  borealis, 382.
  dimidiata, 379.
  immaculata, 384.
  knobelae, 380.
  robusta, 380.
Cyclocephalini with Notes on Burmeister Types, Arkansas, 377.
Cymatodera, 555.
  xavierae, 555.

Dactylocerca, 659.
Davidson, R. H. (with DeLong), Article by, 608.
Davis, Consett, Article by, 677.
DeLong, D. M. (with Davidson), Article by, 608.
Deonier, C. C. (with Knipling), Article by, 578.
Dichelacera, 695.
  analis, 696.
  marginata, 697.
  regina, 699.
Dicladocera, 688.
  badia, 689.
Dorsey, Carl K., Article by, 120.
Dragonfly from Panama, Palaemnema joanetta, a New, 626.
Dragonflies from Ecuador with Notes on Cora, Miocora, Kalocora, Josocora and Stenocora, The Miocora-like, 406.
Dyscinetus, 378.
  trachypygus, 378.

Eckert, J. E., Article by, 258.
Egg Production in the Common Bean Weevil, Acanthoscelides obtectus, Longevity and, 361.
Elytroleptus, 558.
  davisi, 558.
Embiidae, 678.
Embioptera of North America, A Revision of the, 629.
Embioptera, Family Classification of the Order, 677.
Embryology of Prodenia eridania, The Early, 56.
Embryonic Membranes, Yolk Cells, and Morphogenesis of the Stonefly Pteronarcys proteus Newman, 437.
Emergence of a Neotropical Mantispid from a Spider Egg Sac, The, 357.
Emerson, Kary C., Article by, 339.
Empoasca, Studies of the Genus, 608.
Empoasca, 608.
  arator, 610.
  dampfi, 608.
  duodens, 611.
  prona, 610.
  resupina, 611.
  serrula, 608.
Enizemum, 323.
  petiolatum, 323.

Environmental Resistance to the Establishment of Parasitic Hymenoptera, 245.
Eosentomidae, 518.
Eosentomon, 519.
pallidum, 525.
pusillum, 527.
rostratum, 520.
vermiforme, 522.
wheeleri, 523.
yosemitensis, 528.
Ephemera, 325.
decora, 325.
hebes, 325.
simulans, 326.
Ephemeropteran Species of Francis Walker, The North American, 324.
Ephestia elutella and Lasioderma sericorne at Reduced Pressure, Water Vapor as a Factor Affecting the Survival of, 583.
Euembioptera, 677.
Ewing, H. E., Article by, 495.
Exoprosopa, 594.
capucina, 594.

Fairchild, G. B., Articles by, 683, 701.
Fernald, H. T., Articles by, 33, 625.
Flanders, Stanley E., Article by, 245.
Forbes, Wm. T. M., Article by, 588.
Formica sanguinea subintegra Emery, its Raids, Nuptial Flights and Nest Structure, Slave-making Ant, 560.
Fraser, F. C., Article by, 552.
Fulton, B. B., Article by, 231.

Genus Plusinia, The, 588.
Geomysaprinus, 2.
goffi, 3.
tibialis, 5.
Gonomyia, 161.
guerreroensis, 161.
Gopher, New Histeridae (Coleoptera) from the Burrows of the Florida Pocket, 1.
Grasshopper, The Respiratory Mechanism in the, 35.
Gross, James B. (with Howland), Article by, 56.
Growth of the Head Capsule of the Japanese Beetle Larva, The, 385.
Gynembia, 664.
tarsalis, 664.

Harmston, F. C. (with Knowlton), Article by, 395.
Haseman, Leonard (with McLane), Article by, 612.
Hemipterochilus, 173.
Hemocytes to Certain Pathogenes in the Hemolymph, Miotic Response of Roach, 113.
Hesperia, Two New Forms of, 373.
Hesperia, 373.
colorado, 373.
leussleri, 373.
pahaska, 375.
williamsi, 375.
Hexatoma, 159.
plumbeinota, 159.
Histeridae (Coleoptera) from the Burrows of the Florida Pocket Gopher, New, 1.
Histerinae, Histerini, 7.
Honeybee, Studies on the Poison System of the, 258.
Hornworm Parasite, Apanteles congregatus Say and the Hyperparasite, Hypopteromalus tabacum (Fitch), The, 231.
Howland, Ruth B. (with Gross), Article by, 56.
Hubbell, T. H., Article by, 10.
Hypopteromalus, 240.
tabacum, 240.

Insecticides, The Relation Between Exposure Time, Concentration and Toxicity in Experiments on, 721.
Itoplectis, 314.
brevacus, 315.
clavicornis, 315.
conquisitor, 316.
obsesus, 320.
quadricingulatus, 321.

Japanese Beetle Larva, The Growth of the Head Capsule of the, 385.
Josocora, 408.
jocosa, 409.
kleinei, 410.
Juniper Midge, The History and Biology of the, 612.

Kalocora, 407.
Kellogg, Vernon Lyman, Biography of, 599.
Kennedy, Clarence Hamilton, Articles by, 406, 560, 626.
Knipling, E. F. (with Deonier), Article by, 578.
Knowlton, G. F. (with Stains, 77,) (with Harmston, 395,) (with Smith 404).
Knull, Dorothy J., Article by, 371.
Knull, Josef N., Article by, 555.

Lasioderma sericorne at Reduced Pressure, Water Vapor as a Factor Affecting the Survival of Ephestia elutella and, 583.
Leptochiloides, 165.
arizonae, 166.
brevicornis, 167.
utahensis, 166.

Lepturinae, 270.
Limonia, 150.
gracilirama, 150.
lassula, 151.
orthorhabda, 152.
proliferata, 151.
Lindquist, Arthur W., Article by, 103.
Lindsey, A. W., Article by, 373.
Linsley, E. Gorton, Article by, 269.
List of Members, page v in back of June issue.
Livingstone, E. M. (with Reed), Article by, 583.
Longevity and Egg Production in the Common Bean Weevil, Acanthoscelides obtectus (Say), 361.
Ludwig, Daniel (with Abercrombie), Article by, 385.

Macropsis from Texas, Two, 371.
Macropsis, 371.
breakeyi, 371.
davisi, 372.
Mantispid from a Spider Egg Sac, The Emergence of a Neotropical, 357.
McCutcheon, F. H., Article by, 35.
McLane, S. R. (with Haseman), Article by, 612.
Megapterocheilus, 173.
Melittobia, 594.
Mesembia, 643.
haitiana, 646.
hospes, 644.
Mesembiinae, 643.
Microentominae, 533.
Microentomon, 533.
perpusillum, 533.
Microfilm Sets of Periodicals, 208.
Microterocheilus, 201.
Miller, Albert, Article by, 437.
Milliron, H. E., Article by, 357.
Miocora, 416.
pellucida, 418.
peraltica, 417.
subapicalis, 422.
Miocora-like Dragonflies from Ecuador with Notes on Cora, Miocora, Kalocora, Josocora and Stenocora, The, 406.
Miotic Response of Roach Hemocytes to Certain Pathogenes in the Hemolymph, 113.
Mischocyttarus, 90.
ater, 90.
basimacula, 90.
cubensis, 90.
immarginatus, 90.
mexicanus, 90.
Monobia, 95, 593.
angulosa, 593,
nigripennis, 593.
quadridens, 96.
texana, 96.
Monodontomerus, 594.
Montezumia, 96.
arizonensis, 97.
Mordwilko, Doctor, A. K., Biography of, 487.

Necydalini, A Revision of the North American, 269.
Necydalini, 271.
Necydalis, 271.
acutipennis, 275.
barbarae, 272.
californica, 279.
cavipennis, 274.
diversicollis, 278.
laevicollis, 276.
mellita, 273.
seminiger, 277.
Neotropical Elements in the Nearctic Fauna, Monobia, Montezumia and Pachymenes, 95.
Nest-founding by the Wasp, Polistes annularis Linn., Cooperative, 617.
Nesting Habits of Several Species of Mexican Social Wasps, The, 81.
Notice to Authors of Articles which have Appeared in the Annals, 244, 587, 719.
Notoligotomidae, 681.

Oligembia, 636.
brevicauda, 640.
hubbardi, 637.
pacifica, 640.
Oligembiidae, 680.
Oligotoma, 667.
humbertiana, 674.
nigra, 670.
saundersii, 668.
Oligotomidae, 667, 679.
Onchopterocheilus, 191.
Orimarga, 154.
majuscula, 154.
niveitarsis, 154.
subconcinna, 154.
Oxydiscus, 158.
acutissimus, 159.
mexicanus, 158.
Ozodicera, 140.
septemtrionis, 140.

Pachodynerus, 592.
acuticarinatus, 592.
Pachymenes, 100.
sonorensis, 101.
symmorphus, 100.
toltecus, 101.
Palaemnema joanetta, a New Dragonfly from Panama, 626.
Palingenia, 326.
bicolor, 326.

concinna, 327.
natata, 327.
nebulosa, 327.
occulta, 327.
pallipes, 328.
viridescens, 329.
vitrea, 330.
Parasitic Hymenoptera, Environmental Resistance to the Establishment of, 245.
Personal Bibliographies, 224, 624.
Photopsis, 593.
Phymatodis, 556.
ursae, 556.
Pimpla, 298.
aequalis, 308.
aquilonia, 303.
inflata, 306.
maura, 300.
nuda, 306.
pedalis, 301.
sodalis, 300.
tenuicornis, 305.
Pimplini of Eastern North America, A Revision of the, 283.
Plusina, The Genus, 588.
Poison System of the Honeybee, Studies on the, 258.
Polistes, 85.
canadensis, 86.
carnifex, 85.
instabilis, 87.
major, 87.
mexicanus, 86.
Polistes annularis Linn., Cooperative Nest-founding by the Wasp, 617.
Polistes, A Probable Prenuptial Gathering of, 33.
Polybia, 81.
occidentalis, 81.
Polymera, 155.
honesta, 156.
leucopeza, 155.
nodulifera, 157.
Potato Flea Beetle Injuries in Fields Adjoining Uncultivated Areas, Relative Prevalence of, 391.
Prenuptial Gathering of Polistes, A Probable, 33.
Proceedings of the Thirty-fourth Annual Meeting, 209.
Prodenia eridania, The Early Embryology of, 56.
Protembiidae, 677.
Protentomidae, 530.
Protentominae, 530.
Protentomon, 531.
transitans, 532.
Protembioptera, 677.
Protura of North America, The, 495.
Protura, 518.
Proturentomon, 530.
iowaense, 531.
Psalidia, 690.
bahiana, 694.
ocellata, 693.
victoria, 694.
Pseudochilus, 167.
Pseudopterocheilus, 164.
Pterocheilus and Notes on Related Genera, A Revision of the North American Species of, 162.
Pterocheilus diversicolor Rohwer, Additional Notes on, 282.
Pterocheilus, 168, 172, 282.
acuceps, 208.
arizonicus, 174.
bakeri, 198.
biplagiatus, 189.
comptus, 199.
crispocornis, 178.
cyathopus, 206.
decorus, 184.
denticulatus, 180.
desertorum, 202.
diversicolor, 282.
flavobalteatus, 205.
hirsutipennis, 200.
inyoensis, 186.
laticeps, 191.
linsleyi, 176.
mexicanus, 181.
micheneri, 196.
mirandus, 190.
morrisoni, 205.
nigricaudus, 181.
oregonensis, 182.
panamintensis, 192.
pedicellatus, 188.
pimorum, 197.
provancheri, 203.
pruinosus, 203.
quinquefasciatus, 187.
seneconis, 204.
texanus, 185.
timberlakei, 194.
trachysomus, 193.
trichogaster, 183.
tricoloratus, 207.

Rau, Phil, Articles by, 81, 590, 617.
Reed, W. D. (with Livingstone), Article by, 583.
Respiratory Mechanism in the Grasshopper, The, 35.
Rocky Mountain "Black Fly," [Symphoromyia atripes, The, 254.
Ross, Herbert H., Article by, 254.
Ross, Edward S., Articles by, 1, 629.

Sanderson, Milton W., Article by, 377.
Saprininae, 2.
Saussurembia, 647.
venosa, 648.
Scambus, 323.
hirticauda, 323.

Silpha, A Comparative Study of the Larvae of Six Species of, 120.
Silpha, 126.
americana, 126.
inequalis, 127.
lapponica, 129.
noveboracensis, 128.
ramosa, 129.
surinamensis, 130.
Simulidae (Diptera), Three New Western, 77.
Simuliidae of Panama, Notes on the, 701.
Simulium, 77.
clarki, 710.
flaviantennus, 79.
haematopotum, 714.
hardyi, 78.
marathrumi, 715.
metallicum, 712.
mexicanum, 708.
ochraceum, 706.
panamense, 705.
pulverulentum, 716.
samboni, 704.
twinni, 77.
virgatum, 718.
Siphlonurus, 337.
luridipennis, 337.
Slave-making Ant, Formica sanguinea subintegra Emery, its Raids, Nuptial Flights and Nest Structure, 560.
Smith, Clyde F. (with Knowlton), Article by, 404.
Social Wasps, The Nesting Habits of Several Species of Mexican, 81.
Spieth, Herman T., Article by, 324.
Sphaerophthalma, 594.
auripilis, 594.
Spilodiscus floridanus, 7.
Spogostylum, 595.
oedipus, 595.
Stains, G. S. (with Knowlton), Article by, 77.
Stenocora, 411.
Stenonema, 338.
interpunctatum, 338.
Stibasoma, 684.
apicimacula, 686.
chionostigma, 684.
fulvohirtum, 685.
theotaenia, 685.
Stonefly, Pteronarcys proteus Newman, Embryonic Membranes, Yolk Cells, and Morphogenesis of the, 437.
Symphoromyia atripes, The Rocky Mountain "Black Fly," 254.
Sympycnus in Utah, The Genus, 395.
Sympycnus, 397.
binodatus, 397.
fuscitibialis, 400.
hardyi, 397.
isoaristus, 402.
pennarista, 399.
pictipes, 401.
spatulatus, 398.
Tabanidae (Dipt.) from Panama, Notes on, II. The Genus Dichelacera macquart and Related Genera, 683.
Talbot, Mary (with Kennedy), Article by, 560.
Tauber, Oscar E., Article by, 113.
Teratembiidae, 680.
Theronia, 289.
atlantae, 293.
bicincta, 297.
hilaris, 291.
septemtrionalis, 290.
Tipula, 141.
guerreroensis, 149.
hoogstraali, 144.
novaleonensis, 147.
obscuricincta, 145.
parrai, 141.
prichardi, 148.
schizomera, 142.
temperata, 146.
Townes, Henry Keith, Jr., Article by, 283.
Trentepohlia, 160.
subleucoxena, 160.
Trimenopon, 339.
rozeboomi, 339.
Trimenopon from Panama, A New, 339.
Triorophus, 595.
nodiceps, 595.
Tripoxylon, 592.
mexicanum, 592.
texense, 592.
"Type" Specimens, On, 621.
"Type" Specimens, Comments on C. B. Williams' Paper, 625.
Typhloceuthophilus, 10.
floridanus, 12.

Ulochaetes, 279.
leoninus, 280.

Walker, Francis, The North American Ephemeropteran Species of, 324.
Wasps of Mexico and Their Parasites, Some Mud-daubing, 590.
Water Vapor as a Factor Affecting the Survival of Ephestia elutella and Lasioderma sericorne at Reduced Pressure, 583.
Williams, C. B., Article by, 621.
Wolfenbarger, D. O., Article by, 391.

MAILING DATES FOR 1940 ISSUE OF ANNALS

March Number—March 28, 1940.
June Number—July 3, 1940.
September Number—September 30, 1940.
December Number—December 31, 1940.

LIST OF MEMBERS

Entomological Society of America

(JUNE, 1940)

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small caps. and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

'39. Aamodt, T. L., State Entomologist's Office, University Farm, St. Paul, Minn.
'39. Ackermann, Otto, 639 Walnut St., Irwin, Pa. *Lepidoptera.*
'27. ADAMS, C. F., State Board of Health, Jefferson City, Mo. (F. '29). *Diptera.*
'40. Ahrens, Carsten, The 5th Ave. High School, Pittsburgh, Pa.
'10. ALEXANDER, CHARLES P., Massachusetts State College, Amherst, Mass. (F. '20). *Tipulidae.*
'33. Alexander, E. Gordon, Dept. of Biology, Univ. of Colorado, Boulder, Colo. *Orthoptera.*
'13. ALLEE, W. C., Zool. Bldg., Univ. Chicago, Chicago, Ill. (F. '39). *Behavior.*
'25. Allen, H. W., Box 150, Moorestown, New Jersey. *Tiphiidae.*
'39. Allen, Paul B., Jr., 820-B Washington Ave., Wenatchee, Wash.
'32. Amos, John M., Dept. of Ent., Univ. of Delaware, Newark, Delaware. *Coccidae, Cerambycidae.*
'30. Anderson, Edwin J., Agri. Exp. Sta., State College, Pa. *Beekeeping.*
'29. Anderson, Lauren D., Virginia Truck Experiment Station, Norfolk, Va. *Gerridae.*
'37. Anderson, William H., Rm. 429, U. S. National Museum, Washington, D. C. *Coleopterous larvae.*
'39. Andre, Floyd, Bur. Ent. & Pl. Quar., Washington, D. C. *Thysanoptera.*
'37. Anduze, Paul, Direccion de Malariologia, Apartado Postal 1509, Caracas, Venezuela. *Culicidae.*
'32. ANNAND, P. N., Bureau of Entomology, Washington, D. C. (F. '39). *Aphids.*
'28. App, Bernard A., 4700 Music St., New Orleans, La. *Economic Entomology.*
'36. Argo, Virgil N., 545 W. 146th St., New York City, N. Y. *Physiology.*
'23. Armstrong, T., Ent. Lab., Vineland Station, Ontario, Canada. *Scarabaeidae.*
'36. Ashton, Donald F., 402 Horne St., Raleigh, N. C. *Culicidae.*
'37. Assmuth, Rev. Joseph, Fordham University, New York, N. Y. *Isoptera.*
'34. Au, Sung Hin, P. O. Box 3319, Honolulu, Hawaii. *Aphids.*
'29. Audant, Andre, S. N. P. A., Port-au-Prince, Haiti. *Chrysomelidae.*
'33. Auten, Mary, Ashland College, Ashland, Ohio. *Erythroneura.*
'33. AVINOFF, A., Carnegie Museum, Pittsburgh, Pa. (F. '39). *Lepidoptera.*

'37. Babers, Frank H., Research Center, Beltsville, Maryland. *Physiology.*
'25. Babiy, P. Peter, 121 Catherine St., Ithaca, N. Y. *Psammocharidae.*
Ch. *BACK, E. A., Bur. Ent., U. S. Dept. Agric., Washington, D. C. (F. '38). *Asilidae, Aleyrodidae.*
'39. Badertscher, A. Edison, 103 Bonnie Hill Road, Burnbrae Towson, Md. *Insecticides.*
'21. BAERG, W. J., Univ. Arkansas, Fayetteville, Ark. (F. '32). *Poisonous Arthropods.*
'30. *Bailey, J. W., Box 107, Univ. Richmond, Richmond, Va. *Reptilia.*
'11. BAKER, A. C., Laboratorio Entomologico, Calzada Tacuba 295, Colonia Anahuac, Mexico, D. F., Mex. (F. '29). *Aphididae, Aleyrodidae.*
'12. Baker, A. W., Ontario Agri. College, Guelph, Ontario, Canada. *Mallophaga and Coleoptera.*

'22. Baker, Howard, Box 424, St. Joseph, Mo. *Apple and Pecan Insects.*
'36. Baker, Walter C., Bur. Ent. & Pl. Qr., 8 Whippany Road, Morristown, N. J. *Toxicology.*
'28. Balch, R. E., Dom. Ent. Lab., Fredericton, New Brunswick, Canada. *Forest Insects.*
'20. Balduf, W. V., 308 Entomology Bldg., Univ. of Illinois, Urbana, Ill. *Entomophagous insects.*
Ch. *Ball, E. D., Exp. Sta., Univ. Ariz., Tucson, Ariz. (F. '08). *Cicadellidae, Membracidae, Fulgoridae.*
'38. Ballou, Charles H., Estacion Experimental de Agricultura y Zootecnio, El Valle, Distrito Federal, Venezuela. *Economic Entomology.*
'08. Banks, Nathan, Mus. Comp. Zool., Harvard Univ., Cambridge, Mass. (F. '14).
'37. Barber, George W., 56 Hillhouse Ave., New Haven, Conn.
Ch. Barber, H. G., 2222 Q St., N. W., Washington, D. C. (F. '30). *Hemiptera.*
Ch. Barber, H. S., U. S. National Museum, Washington, D. C. (F. '28). *Coleoptera.*
'23. Bare, Clarence O., Box 7062, Richmond, Va. *Notonectidae.*
'29. Bare, O. S., 2325 N. 67th St., Lincoln, Nebr. *Formicidae.*
Ch. Barlow, John, State College, Kingston, Rhode Island. *Corrodentia.*
'26. Barnes, H. F., Rothamsted Exp. Sta., Harpenden, Herts, England. (F. '37). *Cecidomyiidae.*
'28. Barnes, O. L., 1104 Ash Ave., Tempe, Arizona. *Hemileuca, Anastaxus.*
'39. Barrett, John P., 7213 Yates Ave., Chicago, Ill. *Calliphoridae.*
'35. Barrett, W. L., Jr., Box 509, Uvalde, Texas. *Diptera.*
'39. Bartlett, Lawrence M., Fernald Hall, Mass. State College, Amherst, Mass. *Ephemeroptera.*
'18. Basinger, A. J., Citrus Exp. Sta., Riverside, Calif. *Calliphoridae.*
'31. Bates, Marston, Public Health Laboratories, Cairo, Egypt. *Diptera, Trypetidae.*
'24. Beamer, Raymond H., 1000 Missouri St., Lawrence, Kansas. (F. '34). *Homoptera, Cicadellidae.*
'39. Beard, Raimon L., Conn. Agri. Exp. Sta., 123 Huntington St., New Haven, Conn. *Hemiptera.*
'24. Beck, Elmer W., 51 Barbara Road, Waltham, Mass. *Parasites European Corn Borer.*
'29. Bedard, W. Delles, Box 630, Coeur d'Alene, Idaho. *Scolytidae, Braconidae.*
'20. Bedford, Hugh W., Gov't Ent., Agri. Research Serv., Ent. Sect., Wad Medani, Sudan, Africa.
'25. Bell, Ernest L., 150–17 Roosevelt Ave., Flushing, N. Y. *Hesperiidae.*
'36. Bell, Vernon A., 11 Cottage St., Amherst, Mass. *Isoptera.*
Ch. Bentley, G. M., 64 Biology Bldg., Univ. Tenn., Knoxville, Tenn. *Orthoptera.*
'23. Benton, Curtis, Box 495, West Lafayette, Indiana.
'39. Beougher, Judson J., R. F. D. 1, Laurelville, Ohio. *Household Insects.*
'17. *Bequaert, Joseph C., Harvard Med. Sch., Boston, Mass. (F. '34). *Vespidae, Tabanidae.*
'09. Berger, E. W., St. Plant Board, Gainesville, Fla. *Coccidae, Aleyrodidae.*
'36. Bergren, Leslie, Clarkfield, Minn.
'28. Berly, J. A., Div. Ent., Clemson College, S. Carolina. *Coccidae, Odonata.*
'39. Berry, Paul A., care of American Consul, Santiago, Chile.
'34. Bess, Henry A., 56 Hillhouse Ave., New Haven, Conn. *Ecology.*
Ch. Betten, Cornelius, 3 The Circle, Ithaca, New York. (F. '37). *Trichoptera.*
'28. Bibby, F. F., P. O. Box 602, Brownsville, Texas. *Cicadidae.*
'38. Bickley, Wm. E., Jr., University of Maryland, College Park, Maryland. *Chrysopidae.*
'25. Bigger, J. H., 117 Old Agricultural Bldg., Univ. of Illinois, Urbana, Ill. *Plant Resistance to Insect Attack.*
'30. Billings, Samuel C., Insecticide Testing Lab., Beltsville, Maryland. *Mothproofing.*
'31. Bilsing, S. W., College Station, Texas. *Cerambycidae.*
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. (F. '30). *Noctuidae, Papaipema.*
'26. Bird, R. D., Box 250, Brandon, Manitoba, Canada. *Orthoptera.*

'24. Bishop, Sherman C., Dept. Biol., University Rochester, Rochester, N. Y. *Arachnida.*
Ch. BISHOPP, F. C., Bur. Ent., Washington, D. C. (F. '28). *Ixodoidea, Siphonaptera, Anoplura.*
'25. Bissell, Theo. L., Experiment, Georgia. *Aphididae.*
'37. Blackburn, Norris D., Ohio Agri. Exp. Station, Wooster, Ohio. *Chrysomelidae.*
'13. BLACKMAN, M. W., Bureau Entomology, Washington, D. C. (F. '37). *Scolytidae.*
Ch. BLAISDELL, F. E., Sr., California Academy of Sciences, Golden Gate Park, San Francisco, Calif. (F. '24). *Tenebrionidae, Melyridae.*
'28. Blanchard, R. A., Box 32, Urbana, Illinois. *Corn Earworm.*
'32. Blanton, Franklin S., P. O. Box 786, Babylon, L. I., N. Y. *Trypetidae, Ortalidae.*
'30. Blauvelt, Helen Hayden, care of Wm. Savey, Lake Rd., Ithaca, N. Y.
'28. Blauvelt, Wm. E., Comstock Hall, Cornell Univ., Ithaca, N. Y.
'37. Bleasdale, Gale Gates, 409 Eighth St., S. W., Le Mars, Iowa. *Rynchophora.*
'29. Boesel, M. W., R. R. No. 2, Oxford, Ohio. *Chironomidae.*
'37. Bohart, Richard M., Div. of Ent., Univ. California, 405 Hilgard Ave., Los Angeles, Calif. *Strepsiptera, Hymenoptera.*
'28. Borror, Donald J., Dept. of Zool. and Entomology, Ohio State Univ., Columbus, Ohio. *Odonata.*
'14. BOVING, ADAM G., U. S. Nat. Museum, Washington, D. C. (F. '29). *Coleopterous larvae.*
'33. Boyce, A. M., Citrus Exp. Sta., Riverside, Calif. *Trypetidae.*
Ch. BRADLEY, J. C., Cornell Univ., Ithaca, N. Y. (F. '14). *Campsomeris, Vespidae, Scoliidae.*
'19. Bradley, G. H., Box 491, Orlando, Fla. *Diptera, Culicidae.*
'37. Bradley, Wm. G., 1920 Parkwood Ave., Toledo, Ohio. *Tabanidae, Parasitic Hymenoptera.*
'23. Branch, Hazel E., Univ. of Wichita, Wichita, Kansas. *Chironomidae larvae.*
'25. Brandhorst, Carl T., 106 Lincoln St., Seward, Nebraska. *Wasps.*
Ch. BRAUN, ANNETTE F., 2702 May St., Cincinnati, Ohio. (F. '24). *Microlepidoptera.*
'26. Breakey, E. P., Western Washington Exp. Station, Puyallup, Wash. *Cicadellidae.*
'37. Breland, Osmond P., Dept. Zoology, University of Texas, Austin, Texas. *Chalcidoidea.*
'29. Brindley, T. A., Box 73, Moscow, Idaho. *Pea Weevil.*
'33. Briscoe, M. S., Storer College, Harpers Ferry, W. Va. *Culicidae, Simuliidae, Stomaxyidinae.*
'26. BRITTAIN, W. H., McDonald College P. O., Quebec, Canada (F. '37). *Homoptera.*
'20. BROMLEY, STANLEY W., High Ridge Road, Stamford, Connecticut. (F. '37). *Asilidae.*
'39. Brower, Auburn E., 5 Hospital St., Augusta, Maine. *Lepidoptera, Catocala.*
'39. Brown, A. W. A., Div. of Ent., Dept. Agri., Ottawa, Ontario, Canada. *Lepidoptera and Sawfly larvae.*
'33. Brown, F. Martin, Fountain Valley School, Colorado Springs, Colo. *Pieridae of the Americas.*
'26. Brown, W. J., Ent. Branch, Dept. Agri., Ottawa, Canada. *Coleoptera.*
Ch. BRUES, C. T., Biological Laboratory, Harvard University, Cambridge, Mass. (F. '14). *Hymenoptera.*
'30. BRUNER, S. C., Estacion Agronomica, Santiago de las Vegas, Havana, Cuba (F. '37). *Homoptera, Hemiptera of Cuba.*
'27. Brunson, M. H., Box 150, Moorestown, N. J. *Parasites of Oriental Fruit Moth.*
'33. Bryant, Elizabeth B., Mus. Comp. Zool., Cambridge, Mass. *Arachnida.*
'30. Bryant, Owen, Box 4035, Tucson, Ariz. *Diptera, Coleoptera.*
'38. Bryce, P. I., Entomological Lab., Vineland Station, Ontario, Canada. *Fruit Tree Insects.*
'23. Bryson, Harry R., Dept. Entomology, K. S. C., Manhattan, Kansas. *Elateridae, Scarabaeidae.*

'27. Buckell, E. R., Field Crop Insect Laboratory, P. O. Bldg., Kamloops, British Columbia, Canada. *Orthoptera, Odonata.*
Ch. *BUENO, J. R. DE LA TORRE, 311 E. Fourth St., Tucson, Ariz. (F. '28). *Aquatic Hemiptera, Heteroptera.*
'31. Bugbee, Robert E., Dept. Zoology, Fort Hays, Kansas State College, Hays, Kansas. *Eurytomidae.*
'38. Bunn, Ralph W., Box 312, Delta, Utah. *Fulgoridae, Curculionidae.*
Ch. BURGESS, A. F., 20 Sanderson St., Greenfield, Mass. (F. '17). *Carabidae.*
'35. Burks, B. de W., 1209 W. Illinois St., Urbana, Ill. *Chalcididae.*
'27. *Burrell, R. W., P. O. Box 47, Yokohama, Japan. *Thynnidae, Tiphiidae.*
'29. Bushey, Clinton J., Olivet College, Olivet, Ill. *Curculio.*
'33. Bushnell, Ralph J., Univ. of Connecticut, Storrs, Conn. *Conopidae.*
'35. Bussart, J. Everett, 425 East Illinois St., Wheaton, Ill. *Tachinid Biology.*
'30. Butt, F. H., Cornell Univ., Ithaca, N. Y.
'20. Buys, John L., Dept. Biology, St. Lawrence Univ., Canton, N. Y. *Homoptera, Cicadellidae.*
'36. Buzicky, Albert W., 487 St. Clair St., St. Paul, Minn. *Chyphotes.*
'24. Byers, C. Francis, Dept. Biology, Univ. of Florida, Gainesville, Fla. *Odonata.*

'25. Caffrey, D. J., Bureau of Entomology, Washington, D. C.
'35. Caldwell, John S., 535 S. Court St., Circleville, Ohio. *Chermidae.*
Ch. CALVERT, PHILIP P., P. O. Box 14, Cheyney, Pa. (F. '07; H. F. '39). *Odonata.*
'28. CAMPBELL, FRANK LESLIE, Dept. of Zool. and Ent., Ohio State Univ., Columbus, Ohio (F. '34). *Toxicology.*
'13. Campbell, Roy E., P. O. Box 287, Alhambra, Calif.
'14. *Capp, S. B., Box 2054, Philadelphia, Penn.
'33. CARPENTER, F. M., Mus. Comp. Zool., Harvard Univ., Cambridge, Mass. (F. '38). *Mecoptera, Neuroptera.*
'26. Carpentier, Fritz, Inst. Ed. Van Veneden, 10 Rue Vivegnis, Leige, Belgium. *Morphology.*
'31. Carruth, Laurence A., Box 127, Roslyn, Long Island, N. Y. *Meloidae.*
'22. CARTER, WALTER, P. O. Box 3166, Honolulu, T. H. (F. '38). *Insect transmission of plant diseases.*
'26. Cartwright, O. L., Agri. Exp. Station, Clemson College, Clemson College, S. C. *Scarabaeidae.*
'26. Cartwright, William B., Box 495, Lafayette, Ind. *Hessian Fly.*
'29. Cecil, R., P. O. Box 1330, Ventura, Calif. *Bean Insects.*
'29. Cendana, S. M., Agricultural College, Laguna, P. I. *Coccinellidae.*
'22. CHAMBERLIN, JOSEPH C., P. O. Box 278, Forest Grove, Oregon (F. '38). *Chelonethida.*
Ch. CHAMBERLIN, R. V., Univ. Utah, Salt Lake City, Utah (F. '17). *Myriapoda, Arachnida.*
'18. Chambers, Ernest L., Room 9, W. Wing, State Capitol, Madison, Wis.
'14. Champion, H. G., Forest Research Inst., Dehra Dun, U. P. India. *Coleoptera.*
'15. Chapman, James W., Silliman Inst., Dumaguete, Philippine Islands. *Ants of P. I.*
'13. Childs, Leroy, Hood River, Oregon. *Apple and Pear Insects.*
'30. Christenson, D., Bur. of Ent. and P. Q., 1583 D St., San Bernardino, Calif. *Aptera, Myriapoda.*
'27. Clagg, C. F., Barnstable, Mass. *Mecoptera, Hemiptera.*
'22. Clark, Chas. A., Box 150, Moorestown, N. J. *Odonata, Ichneumonidae.*
'30. Clarke, Wm. H., Box 69, Thomaston, Georgia. *Orthoptera, Lepidoptera.*
'34. Clarke-Macintyre, William, Zool. and Ent. Museums of the Universidad Central, Apartado 166, Quito, Rep. del Ecuador. *Rhopolocera of Ecuador.*
'14. CLAUSEN, CURTIS P., Bur. Entomology and P. Q., Washington, D. C. (F. '37). *Insect Parasites.*
'07. COCKERELL, T. D. A., 908 Tenth St., Boulder, Colo. (F. '08; H. F. '37). *Bees, Fossil Insects.*
'39. Colcord, Mabel, 2520 Fourteenth St. N. W., Washington, D. C. *Bibliography.*

'28. Cole, Arthur C., Jr., Dept. of Entomology, Univ. of Tennessee, Knoxville, Tenn.
'16. COLE, F. R., P. O. Box No. 6, Redlands, Calif. (F. '38). *Diptera, Hymenoptera.*
'16. Collins, C. W., Bureau of Ent. and Plant Quar., 8 Whippany Road, Morristown, N. J. *Insect vectors of Dutch Elm Disease.*
'29. Collins, Donald L., Boyce Thompson Institute for Plant Research, Yonkers, N. Y. *Codling Moth, Dutch Elm Disease Insects.*
'21. Compton, Chas. C., Floriculture Bldg., Urbana, Ill. *Greenhouse and Truck Insects.*
'29. Conklin, J. G., Dept. Ent., Univ. New Hampshire, Durham, N. H. *Coccinellidae.*
'35. Connell, Walter A., West Grove, Pa. *Diptera.*
Ch. Cook, Mel T., care of Dr. Harold T. Cook, Truck Crop Exp. Sta., Norfolk, Va. *Entomogenous Fungi.*
'19. COOK, WM. C., 425 Santa Rita Ave., Modesto, Calif. (F. '38). *Noctuidae.*
'10. COOLEY, R. A., U. S. Public Health Service, Hamilton, Mont. (F. '24). *Ixodidae, Ixodiphiginae.*
'36. Cooper, James Furman, 503 Realty Bldg., Spokane, Wash. *Japanese Beetle.*
'40. Cooper, Robert H., Ball State Teachers College, Muncie, Ind.
'39. Cope, Oliver B., Natural History Museum, Stanford Univ., Calif. *Anoplura, Mallophaga, Diptera Pupipara.*
'36. Coronel, Arsenio Y., Agri. College, Laguna Province, Philippine Islands. *Lepidopterous Larvae.*
'32. Cory, Ernest N., State Entomologist, College Park, Maryland.
'21. COSTA-LIMA, ANGELO M. DA, Institute Oswaldo Cruz, Caixa Postal-926, Rio de Janeiro, Brazil (F. '39). *Economic Entomology.*
'15. COTTON, RICHARD T., 343 N. 14th St., Manhattan, Kans. (F. '37). *Curculionid Larvae.*
'35. Couture, Philip, 6 Mill Road, Durham, N. H.
'11. *CRAMPTON, G. C., 86 Pleasant St., Amherst, Mass. (F. '17). *Morphology.*
'36. Crandall, Herbert A., 1436 Meadow Road, Columbus, Ohio. *Insecticides.*
'39. Crandall, Robert H., 2208 E. Third St., Tucson, Ariz.
'34. Crawford, Wiley William, Care of Blackburn College, Carlinville, Ill.
'33. Creighton, John T., Univ. of Florida, Gainesville, Fla. *Economic Entomology.*
Ch. CRESSON, E. T., JR., 11 Amherst Ave., Swarthmore, Penn. (F. '24). *Ephydridae, Micropezidae.*
'38. Crowell, H. H., Dept. Zool.-Ent., Ohio State Univ., Columbus, Ohio. *Physiology.*
'15. CURRAN, C. H., Am. Mus. Nat. Hist., 77th St., Central Park W., New York, N. Y. (F. '34). *Diptera.*
'38. Curtiss, Charles, 1127 Valtier St., Manhattan, Kans. *Miridae.*
'21. Cutright, Clifford R., Agri. Exp. Sta., Wooster, Ohio. *Aphidae.*

'35. Daggy, Richard H., Div. of Entomology, Univ. Farm, St. Paul, Minn. *Ephemeroptera.*
'38. Dahm, Paul A., Dept. of Entomology, Univ. of Illinois, Urbana, Ill. *Phymatidae.*
'32. Daniel, Derrill M., N. Y. Agri. Exp. Sta., Geneva, N. Y. *Ichneumonidae, Braconidae.*
'29. Darley, Merrill M., P. O. Box 149, Long Island City, N. Y. *Insecticides.*
'25. DARLINGTON, P. J., JR., Mus. Comp. Zool., Cambridge, Mass. (F. '38). *Adephaga, Dryopidae.*
'30. Davidson, Ralph H., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Cicadellidae.*
'22. Davis, E. W., 425 Santa Rita Ave., Modesto, Calif. *Cicadellidae.*
Ch. DAVIS, J. J., Purdue Univ., Lafayette, Ind. (F. '17). *Aphididae, Lachnosterna.*
Ch. *DAVIS, WM. T., 146 Stuyvesant Place, Staten Island, N. Y. (F. '17). *Cicadidae, Orthoptera.*
'13. DEAN, GEO. A., K. S. C., Manhattan, Kans. (F. '17). *Economic Entomology.*
'33. Dean, R. W., 33 Marple Road, Poughkeepsie, N. Y. *Morphology.*

'36. Dearolf, Kenneth, Public Library Museum, Dayton, Ohio. *Cave Insects.*
'25. Deay, Howard O., Dept. Ent., Purdue Univ., Lafayette, Ind. *Coreidae, Tenagobia, Micronecta.*
'38. DeBach, Paul H., Citrus Experiment Station, Riverside, Calif. *Chalcidoidea.*
'24. Decker, Geo. C., Dept. Zool. and Ent., Iowa State College, Ames, Iowa. *Stalk Borers, Crambus.*
'24. DeCoursey, R. M., Connecticut Agri. College, Storrs, Conn. *Hemiptera.*
'29. DeLeon, Donald, 209 Forestry Bldg., Fort Collins, Colo. *Scolytidae.*
'14. DeLong, D. M., Dept. Ent., Ohio State Univ., Columbus, Ohio (F.'30). *Cicadellidae.*
'36. Del Ponte, Edward, Instituto Bacteriologico, Calle Velez Sarsfield 563, Dept. Nac. de Hygiene, Buenos Ayres, Argentine. *Parasitic Insects.*
'31. Denis, J. R., Laboratoire de Zoologie, Faculte des Sciences, Univ. of Dijon Dijon (Cote d'Or), France. *Apterygota.*
'34. Denning, Donald G., Div. of Ent., Univ. of Minnesota, St. Paul, Minn. *Trichoptera, Corethrinae.*
'37. Dennis, Clyde A., Tusculum College, Greeneville, Tenn.
'34. Deonier, C. C., Nice, Lake County, Calif. *Muscidae.*
'20. Detwiler, John D., Univ. Western Ont., London, Ont., Canada. *Corn Borer Problems.*
'27. Dicke, Ferdinand F., Arlington Farm, Arlington, Va. *Harmolita Parasites.*
'39. Dickson, Robert C., Dept. Ent., Citrus Exp. Sta., Riverside, Calif. *Aphididae.*
'22. Dietrich, Henry, Comstock Hall, Cornell Univ., Ithaca, N. Y. *Coleoptera.*
'35. Dillon, Lawrence Samuel, 316 Woodside Ave., West Lawn, Penn. *Cerambycidae.*
'24. Dills, L. E., Exp. Sta. Bldg., State College, Penn.
'26. Dirks, C. O., Dept. Bot. and Ent., Orono, Maine. *Biology of Lepidoptera.*
'31. Ditman, L. P., Univ. Maryland, College Park, Md. *Tingidae.*
'27. *Doak, K. D., 1327 Kenyon St. N. W., Washington, D. C. *Gelechiidae.*
'28. Dobbins, Traber N., Jap. Beetle Lab., Moorestown, N. J. *Pecan Phylloxera.*
'38. Dobkin, Irving B., 3435 W. 18th St., Chicago, Ill. *Physiology.*
'36. *Dodge, Harold R., Clintonville, Wis. *Scolytidae.*
'22. Doering, Kathlene C., Dept. Ent., Univ. Kansas, Lawrence, Kans. (F. '35). *Cercopidae, Fulgoridae.*
'28. Doner, Melvin H., The J. R. Watkins Co., 150–178 Liberty St., Winona, Minn. *History of Insect Classification.*
'31. Donohoe, Heber C., P. O. Box 1, Trenton, N. J. *Japanese Beetle.*
'37. Dorst, Howard E., Utah Agri. College, Logan, Utah. *Cicadellidae.*
'22. Doucette, Chas. F., Box 458, Sumner, Wash. *Ornamental Insects.*
'23. Douglass, J. R., Box 1100, Twin Falls, Idaho. *Chrysomelidae.*
'28. Dove, W. E., Box 341, Arlington, Va. *Animal Parasites.*
'31. Dow, Richard, New England Museum of Natural History, 234 Berkeley St., Boston, Mass. *Sphecoid Wasps.*
'22. Dowden, Philip B., 56 Hillhouse Ave., New Haven, Conn. *Parasitic Hymenoptera.*
'22. Drake, Carl J., Iowa State College, Ames, Iowa. (F. '31). *Tingitidae.*
'37. Dreisbach, Robert R., 806 Mill St., Midland, Michigan. *Vespidae.*
'31. Driggers, Byrley F., Agri. Exp. Sta., New Brunswick, N. J. *Economic Entomology.*
'38. Drolet, Marcel, 95 Ste. Foy Road, Quebec, Quebec, Canada. *Cerambycidae.*
'26. Dunavan, David, 148 Calhoun Circle, Clemson, South Carolina. *Haliplidae.*
'23. Duncan, Carl D., Box 4, Stanford Univ., Calif. *Vespidae, Bembicidae.*
'28. Dunnam, E. W., Box 8, Leland, Miss. *Cotton Resistance to Insects.*
'16. DuPorte, E. Melville, Macdonald College, Quebec, Canada. *Diptera, Ixodoidea.*
'14. Dusham, E. H., 607 N. Burrowes St., State College, Penn. *Coleoptera.*

Ch. Easton, Norman S., 458 High St., Fall River, Mass. *Coleoptera*
'38. Eaton, Charles B., 335 Giannini Hall, Univ. of Calif., Berkeley, Calif. *Scolytidae.*
'31. Eckert, J. E., Box 381, Davis, Calif. *Beekeeping.*

'36. Eddy, Brayton, 52 Taber Ave., Providence, R. I.
'23. EDDY, C. O., Louisiana Exp. Station, Agr. Center, University, La. (F. '31).
'39. Edelblute, Lyle H., 1212 A Thurston St., Manhattan, Kans. *Bolbocerini.*
'31. Elliott, D. C., Southwestern La. Institute, Lafayette, Louisiana. *Aphids.*
'24. Elmore, J. C., Box 287, Alhambra, Calif. *Truck Crop Insects.*
'27. Elson, J. A., Gustavus Adolphus College, St. Peter, Minn. *Morphology.*
'36. Elster, Oscar G. R., Eveleth, Minn.
'19. EMERSON, ALFRED E., Dept. Zool., Univ. Chicago, Chicago, Ill. (F. '37). *Isoptera, Termitophiles.*
'38. Emerson, K. C., Dept. Ent., Okla. A. & M. College, Stillwater, Okla. *Mallophaga.*
'25. Enders, Howard E., 249 Littleton St., West Lafayette, Ind. *Mallophaga.*
Ch. ENGELHARDT, GEORGE P., 28 Club Way, Hartsdale, N. Y. (F. '32). *Aegeriidae.*
'38. Epstein, Erwin J., 3264 Cedarbrook Road, Cleveland Heights, Ohio.
'10. ESSIG, E. O., Univ. of Calif., Berkeley, Calif. (F. '26). *Aphididae, Coccidae.*
'29. Evans, J. Harwood, Oshkosh High School, Oshkosh, Wis. *Phymatidae.*
'30. Everly, Ray T., Holmesville, Holmes Co., Ohio. *Carabidae.*
'10. EWING, HENRY E., U. S. Nat. Museum, Washington, D. C. (F. '28). *Acarina.*
'18. EYER, JOHN R., State College, New Mexico. (F. '38). *Cicadellidae, Chermidae.*

'32. Fairchild, Graham Bell, Box 5025, Gorgas Memorial Inst., Ancon, Canal Zone. *Culicidae, Tabanidae.*
'35. Falls, Olive, 6218 So. Woodlawn Ave, Chicago, Ill.
'30. Farquhar, Donald W., 296 Ames St., Lawrence, Mass. *Lepidoptera of New England.*
'31. Farrar, M. D., State Ent. Bldg., Urbana, Ill. *Economic Entomology.*
'17. Fattig, P. W., Box 788, Emory University, Ga.
'34. Fay, Richard William, 1351 Early Ave., Chicago, Ill. *Chrysomelidae.*
Ch. FELT, E. P., Bartlett Tree Research Lab., Stamford, Conn. (F. '08). *Gall midges.*
'30. Feng, Hsiao-Tang, 9 Chen Hong, Wushih, Kiangau, China. *Dytiscidae.*
'36. Fenton, Alfred S., 1103-04 Second National Bank Bldg., Houston, Texas.
Ch. FERNALD, H. T., 1128 Oxford Road, Winter Park, Fla. (F. '14, H. F. '37). *Sphecidae.*
'14. FERRIS, G. F., Natural History Museum, Stanford Univ., Calif. (F. '34). *Coccidae, Mallophaga, Anoplura, Diptera.*
'27. Ficht, George A., P. O. Box 408, Auburn, Ind. *Noctuidae.*
'35. Field, William D., Dept. of Entomology, Univ. of Kansas, Lawrence, Kans. *Lepidoptera.*
Ch. Field, Wm. L. W., 75 Vose's Lane, Milton, Mass.
'31. Filmer, Robert Sterling, Rutgers Univ., New Brunswick, N. J. *Insecticides, Bees.*
'38. Filsinger, Carl, 1114 Grandview Ave., Westfield, N. J. *Economic Entomology.*
'35. Fisher, Elizabeth G., 20 Blythewood Road, Roland Park P. O., Baltimore, Maryland. *Odonata, Mycetophilidae, Insect Morphology.*
'36. Fisk, Frank Wilbur, U. S. Quarantine Station, P. O. Box 97, Terminal Island, Calif. *Culicidae.*
'30. FLANDERS, STANLEY E., Citrus Exp. Sta., Riverside, Calif. (F. '37). *Biology of Chalcidoidea.*
'31. Fletcher, Fred W., Biochem. Dept., Dow Chemical Co., Midland, Mich. *Insecticides.*
'19. Fletcher, Robert K., Box 152, Faculty Exch., College Station, Texas. *Cicadellidae.*
'08. FLINT, WESLEY P., St. Ent. Bldg., Urbana, Ill. (F. '31). *Economic Entomology.*
'24. FLUKE, C. L., King Hall, Univ. of Wisconsin, Madison, Wis. (F. '35). *Syrphidae.*
'38. Forbes, James, Dept. Biology, Fordham Univ., New York, N. Y. *Formicidae.*
'08. *FORBES, WM. T. M., Cornell Univ., Ithaca, N. Y. (F. '30). *Lepidoptera, Neuropteroids.*
'30. Foster, Charles E., Colgate Univ., Hamilton, N. Y. *Coccidae.*
'20. *Fournier, Mrs. Gaston, 90 Boul. Malesherbes, Paris 8, France. *Lepidoptera.*
'31. Fox, David E., Box 1100, Twin Falls, Idaho. *Ecology.*

'11. FRACKER, S. B., Bureau of Ent. & Plant Quar., U. S. Dept. Agric., Washington, D. C. (F. '34). *Coreidae.*
'23. FREEBORN, STANLEY B., 101 Giannini Hall, Univ. of Calif., Berkeley, Calif. (F. '38.) *Culicidae.*
'37. Freeman, Thomas N., Ent. Branch, Dept. of Agri., Ottawa, Ontario, Canada. *Lepidoptera.*
'22. FRIEND, ROGER B., Agri. Exp. Sta., 153 Huntington St., New Haven, Conn. (F. '38). *Diptera.*
'14. FRISON, T. H., Nat. Hist. Bldg., Univ. Ill., Urbana, Ill. (F. '29). *Plecoptera and Bombidae.*
Ch. Frost, C. A., 67 Henry St., Framingham, Mass. *Coleoptera.*
'14. FROST, STUART W., 465 E. Foster Ave., State College, Pa. (F. '35). *Agromyzidae, Hispinae.*
Ch. Fullaway, D. T., Board Agri., Box 3319, Honolulu, Hawaii. *Parasitic Hymenoptera.*
'16. FULTON, B. B., State College, Raleigh, North Carolina. (F. '32). *Orthoptera.*
'11. FUNKHOUSER, WM. D., Univ. Kentucky, Lexington, Ky. (F. '20). *Membracidae.*

Ch. GAHAN, A. B., U. S. Nat. Museum, Washington, D. C. (F. '28). *Chalcidoidea.*
'16. GAIGE, F. M., Mus. Zool., Univ. Mich., Ann Arbor, Mich. (F. '38). *Formicidae.*
'37. Gardner, Theodore R., Bur. of Ent. & Pl. Quar., Box 150, Moorestown, N. J. *Parasites.*
'22. Garlick, W. G. P., Vineland Station, Ontario, Canada. *Tenthredinoidea.*
'14. GARMAN, PHILIP, Agri. Exp. Sta., New Haven, Conn. (F. '38). *Odonata, Acarina.*
'39. Gauthier, Georges, Entomologiste, Ministère de l'Agriculture, Quebec, Quebec, Canada.
'16. Gentner, Louis G., 44 N. Orange St., Medford, Oregon. *Halticinae.*
Ch. Gerhard, Wm. J., Field Museum Nat. Hist., Chicago, Ill. *Hemiptera.*
'22. Gerry, Bertram I., Box 28, Wellesley Hills, Mass. *Culicidae and Chironomidae.*
'32. Gertsch, Willis J., Am. Mus. Nat. Hist., 77th St. and Central Park W., N. Y., N. Y. *Arachnida.*
Ch. GIBSON, ARTHUR, Dominion Entomologist, Ottawa, Ontario, Canada. (F. '17).
'14. Gibson, E. H., Trinity Episcopal Church, Galveston, Texas. *Hemiptera.*
Ch. GILLETTE, C. P., Agri. College, Fort Collins, Colo. (F. '07, H. F. '37). *Aphididae.*
'21. Gilmer, Paul M., Coastal Plains Exper. Sta., Tifton, Georgia. *Cotton Insects.*
'16. Glaser, R. W., Rockefeller Med. Res. Inst., Princeton, N. J. *Insect Diseases.*
'11. Glasgow, Hugh, Experiment Sta., Geneva, New York.
'11. Glasgow, Robert D., State Education Bldg., Albany, N. Y. *Forest Insects.*
'38. Gleissner, Bruce D., Dept. Zool-Ent., Ohio State Univ., Columbus, Ohio.
'39. Glick, Perry A., Box 1218, Waco, Texas. *Ecology.*
'33. Glover, L. C., Box 486, T. Hall, Durham, N. H. *Carabidae, Cerambycidae.*
'30. Glover, Louise Haas, Box 486, T. Hall, Durham, N. H. *Carabidae.*
'30. Good, Newell E., U. S. Pub. Health Serv. Lab., 14th Ave. & Lake Sts., San Francisco, Calif. *Siphonaptera.*
'36. Gouck, Harry K., 10 Burnham Road, Andover, Mass. *Plecoptera.*
'31. Gould, Geo. E., Purdue Univ., Lafayette, Ind. *Rhagovelia, Semiaquatic Hemiptera.*
'39. Graham, Lewis T., Dept. Zool. & Ent., Iowa State College, Ames, Iowa. *Membracidae.*
'17. GRAHAM, SAMUEL A., Univ. of Mich., Ann Arbor, Mich. (F. '32). *Forest Insects.*
'22. GRANOVSKY, A. A., Div. Ent., University Farm, St. Paul, Minn. (F. '35). *Aphiidae.*
'25. Grant, U. S. IV, Nat. Hist. Museum, Balboa Park, San Diego, Calif.
'14. Greene, Chas. T., Box 182, College Park, Maryland. *Diptera.*
'24. Greer, A. H., Box 191, Calexico, California. *Heterocera, Culicidae.*

'36. *Gressitt, J. Linsley, Dept. Biology, Lingnan Univ., Canton, China. *Coleoptera.*
'34. Griffith, Melvin E., Dept. of Zool., North Dakota Ag. College, Fargo, N. D. *Alconeura, Collembola.*
'20. Griswold, Grace H., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Aphididae.*
'36. Gross, James B., Dept. of Biology, New York University, Washington Square, New York, N. Y. *Collembola.*
'33. Gurney, Ashley B., Div. of Insect Identifications, Bur. of Ent. & P. Q., U. S. D. A., Washington, D. C. *Orthoptera, Zoroptera, Corrodentia.*
'16. Guyton, T. L., 2204 Chestnut St., Harrisburg, Pa. *Aphididae.*
'34. Gyger, May Katharyn, Dept. of Ent., Cornell Univ., Ithaca, N. Y. *Odonata.*

'25. Haber, Vernon R., 355 West Ridge Ave., State College, Penn. *Orthoptera.*
'27. *Hadden, Fred C., Midway Island, Pacific Ocean, U. S. A. *Histeridae, Cicindelidae.*
'23. Hadley, C. H., Bureau Entomology, Moorestown, N. J. *Japanese Beetle.*
'24. Haeussler, Gilbert J., U. S. D. A., P. O. Box 150, Moorestown, N. J. *Ichneumonidae, Braconidae.*
'14. HAGAN, HAROLD R., Dept. Biology, College of the City of New York, N. Y. (F. '38). *Embryology.*
'37. Hagmann, Lyle E., Dept. of Ent., Cornell Univ., Ithaca, N. Y. *Physiology.*
'25. Hall, David G., Bur. Ent. and P. Q., Washington, D. C. *Sarcophagidae, Diptera.*
'14. Hamilton, Clyde C., Dept. Ent., Rutgers College, New Brunswick, N. J.
'16. Hamlin, John C., 481 Federal Bldg., Salt Lake City, Utah. *Chelinidea.*
'22. Hamner, A. L., Box 223, State College, Miss. *Aphididae, Phylloxera.*
'37. Handford, Richard H., Box 250, Brandon, Manitoba, Canada. *Acrididae.*
'38. Hansen, Leonard L., Dept. of Entomology, Utah Agri. College, Logan, Utah. *Aphididae and Orthoptera.*
'39. Hanson, John F., Fernald Hall, Massachusetts State College, Amherst, Mass. *Plecoptera.*
'39. Harden, Philip H., Div. of Entomology, Univ. Farm, St. Paul, Minn. *Plecoptera.*
'37. Hardy, D. Elmo, Dept. of Entomology, University of Kansas, Lawrence, Kans. *Pipunculidae, Bibionidae.*
'36. Harmston, Fred Carl, Dept. of Ent., Utah State Agri. College, Logan, Utah. *Dolichopodidae.*
'07. *HARNED, R. W., Bur. Ent. and P. Q., Washington, D. C. (F. '27).
'33. Harper, Lawrence C., R. 1, Lafayette, N. Y.
'29. Harries, F. H., Box 1100, Twin Falls, Idaho. *Ecology, Physiology.*
'23. HARRIS, HALBERT M., Dept. Zool. and Ent., Iowa State College, Ames, Iowa (F. '37). *Hemiptera.*
'39. Hartnack, Hugo, P. O. Box 333, Highland Park, Ill.
'21. Hartzell, Albert, Boyce Thompson Inst., Yonkers, N. Y. *Cicadellidae.*
.07. Hartzell, F. Z., Agri. Exp. Sta., Geneva, N. Y. *Economic Entomology.*
Ch. Haseman, Leonard, Univ. of Missouri, Columbia, Mo. *Psychodidae.*
'32. Haskins, Caryl P., 1188 Avon Road, Schenectady, N. Y. *Hymenoptera,* esp. *Formicidae.*
'20. HATCH, MELVILLE H., Dept. Zool., Univ. Washington, Seattle, Wash. (F. '38). *Coleoptera.*
'38. Hathaway, Edward S., Dept. of Zoology, Tulane Univ., New Orleans, La. *Ecology of Marsh Insects.*
'32. Haub, James G., Dept. of Zoology, Ohio State Univ., Columbus, Ohio. *Physiology.*
'39. Haude, Wm. J., Care of John Powell & Co., Inc., 114 E. 32nd St., New York, N. Y. *Culicidae.*
'30. Haug, Gordon W., Kelowna, British Columbia, Canada. *Formicidae.*
'27. Hawkins, J. H., Agri. Exp. Sta., Orono, Maine. *Elaterid and Noctuid Larvae.*
'32. Hawley, I. M., P. O. Box 518, Spencer, N. Car. *Japanese Beetle.*
'35. Haydak, M. H., Ent. Div., University Farm, St. Paul, Minn. *Honeybee nutrition.*
'19. HAYES, WM. P., Entomology Bldg., Univ. of Illinois, Urbana, Ill. (F. '29). *Larvae.*

Ch. HEADLEE, THOMAS J., Agri. Exp. Sta., New Brunswick, N. J. (F. '20).
'31. Heaton, Robert R., 1128 N. Riley St., Indianapolis, Ind. *Fulgoridae, Homoptera.*
'34. Hendee, Esther C., Dept. Biology, Russell Sage College, Troy, N. Y. *Isoptera, Hymenoptera.*
'32. Henderson, Chas. F., 641 Ramona, Whittier, Calif. *Parasites of Scale Insects.*
'31. Henderson, Lyman S., 305 S. Fifth St., Florala, Ala. *Curculionidae.*
'32. Henderson, W. W., Agri. Exp. Sta., Logan, Utah. *Oedipodinae, Orthoptera.*
Ch. HENSHAW, SAMUEL, 28 Fayerweather St., Cambridge, Mass. (F. '07).
'29. Hering, Paul E., Social Circle, Ga. *Economic Entomology.*
'25. HERMS, WM. B., 112 Agri. Hall, Univ. California, Berkeley, Calif. (F. '29). *Med. Entomology.*
Ch. HERRICK, GLENN W., 219 Kelvin Place, Ithaca, N. Y. (F. '14). *Thysanoptera, Coccidae.*
'28. Hickman, J. R., Normal College, Ypsilanti, Mich. *Haliplidae.*
'30. Hicks, Chas. H., P. O. Box 812, Burbank, Calif. *Triepeolus, Epeolus.*
.08. HILTON, WM. A., 1263 Dartmouth Ave., Claremont, Calif. (F. '39). *Symphyla, Pauropoda.*
'27. HINMAN, E. HAROLD, Division of Malaria Control, Tennessee Valley Authority, Wilson Dam, Ala. (F. '37). *Culicidae.*
'33. Hinton, Howard E., Dept. of Zool., Univ. of Cambridge, Downing St., Cambridge, England. *Dryopidae.*
'34. Hitchcock, John David, Intermountain Bee Culture Field Laboratory, Laramie, Wyo. *Bacteriology of Bee Diseases.*
'38. Hitchcock, O. B., 711 West Yellowstone, Billings, Mont. *Mormon Cricket.*
'27. Hockenyos, Geo. L., 213 E. Jefferson St., Springfield, Ill. *Economic Entomology.*
'38. Hodge, Charles 4th, Dept. of Biology, Temple Univ., Philadelphia, Pa. *Coleoptera.*
Ch. Hodgkiss, H. E., Exp. Sta. Bldg., State College, Penn. *Eriophyiidae.*
'29. Hodson, A. C., Div. Entomology, Univ. Farm, St. Paul, Minn. *Ecology.*
'14. *Hoffman, W. A., Sch. Trop. Med., San Juan, Porto Rico. *Biting Flies.*
'39. Hoffmann, Carlos C., Apartado 8026, Mexico, D. F., Mexico. *Medical Entomology and Lepidoptera.*
'29. Hoffmann, Clarence H., 157 Tacoma Circle, Asheville, N. Car. *Scarabaeidae.*
'20. HOFFMANN, WM. E., Lingnan Univ., Canton, China. (F. '39). *Hemiptera.*
'39. Holloway, James K., P. O. Box 70, Whittier, Calif. *Parasitic Hymenoptera.*
'35. Holway, Richard T., South Duxbury, Mass. *Termites.*
Ch. HOOD, J. DOUGLAS, Dept. Entomology, Cornell Univ., Ithaca, N. Y. (F. '32). *Thysanoptera.*
'38. Hoogstraal, Harry, 24 E. 102nd St., Chicago, Ill. *Morphology.*
'37. Hopping, George R., Box 308, Vernon, British Columbia, Canada. *Cerambycidae.*
'27. Hopping, Ralph, Box 308, Vernon, British Columbia, Canada. *Cerambycidae.*
'34. Horsfall, William R., 20 S. Duncan St., Fayetteville, Ark.
'34. Hoskins, W. M., 112 Agri. Hall, Univ. of California, Berkeley, Calif. *Physiology.*
'24. Hough, W. S., Winchester, Va. *Apple Insects.*
Ch. HOUSER, J. S., Agri. Exp. Sta., Wooster, Ohio (F. '31). *Economic Entomology.*
'39. Hovey, Charles L., Div. Ent., University Farm, St. Paul, Minn.
Ch. HOWARD, L. O., Bur. Ent. and P. Q., Washington, D. C. (F. '07; H. F. '24). *Chalcidoidea.*
'14. Howard, Neale F., 151 W. Eleventh Ave., Columbus, Ohio. *Mexican Bean Beetle.*
'39. Howland, A. F., P. O. Box 287, Alhambra, Calif.
'23. HUBBELL, THEO. H., Dept. Biology, Univ. of Florida, Gainesville, Fla. (F. '39). *Orthoptera.*
'20. HUCKETT, H. C., Long Island Vegetable Res. Farm, Riverhead, L. I., N. Y. (F. '38). *Muscidae.*
'30. Hughes, Miss Gwladys F., St. James Apts., Charles and Center Sts., Baltimore, Md. *Odonata.*
'39. Hughes, John H., Div. of Ent. Univ. Farm, St. Paul, Minn. *Chrysomelidae.*

'16. HUNGERFORD, H. B., 323 Snow Hall, Univ. of Kansas, Lawrence, Kans. (F. '27). *Aquatic Hemiptera.*
'36. Hurlbut, Herbert S., Malaria Studies and Control Div., Tennessee Valley Authority, Wilson Dam, Ala. *Culicidae.*
'34. Hussey, Priscilla B., Professor of Biology, Louisiana State Normal College, Natchitoches, La. *Hemiptera.*
'29. Hutchins, Annie Laurie (Mrs. R. E.), Box 184, State College, Miss. *Coccidae.*
'30. Hutchins, Ross E., Box 184, State College, Miss. *Lepidoptera.*
'38. Hutson, Ray, Dept. of Entomology, Michigan State College, E. Lansing, Mich. *Insecticides.*
'08. HYSLOP, JAMES A., Silver Spring, Md. (F. '35). *Elateridae.*

'31. Ide, F. P., Dept. Biol., Univ. of Toronto, Toronto 5, Ontario, Canada. *Ephemeroptera.*
'19. *Illingworth, J. F., Bishop Museum, Honolulu, Hawaii. *Muscoidea.*
'28. Ingram, J. W., Box 387, Houma, La. *Sugarcane Insects.*
'14. ISELY, DWIGHT, Box 3, University Station, Fayetteville, Ark. (F. '34). *Chrysomelidae, Curculionidae.*
'36. Isely, F. B., Trinity Univ., Waxahachie, Texas. *Acrididae.*
'22. Ishimori, Naoto, Faculty Agri., Imp. Univ., Hongo, Tokyo, Japan. *Silkwork Diseases.*
'33. Issiki, Syuti, Taihoku Imperial Univ., Taihoku, Formosa, Japan.
'27. Ives, J. D., Jefferson City, Tenn. *Cave Insects.*
'34. Ivy, Edward E., Dept. of Entomology, State Agri. College, Stillwater, Okla.

'36. Jackman, Donald L., 3037 Holmes Ave. S., Minneapolis, Minn. *Otitidae.*
'38. James, Freburn L., Box 327, Saranac, Mich. *Coleoptera.*
'31. James, Maurice T., Dept. of Ent., Colorado State College, Ft. Collins, Colo. *Stratiomyiidae.*
'30. Janes, Melvin J., Texas Experiment Station, Alta Loma, Texas. *Economic Entomology.*
'35. Jaques, Harry E., 709 N. Main, Mount Pleasant, Iowa. *Insect Ecology.*
'30. Jaynes, H. A., Bureau of Ent. and P. Q., Moorestown, N. J. *Tiphia of S. A.*
'25. JEANNEL, RENE, Mus. d'Histoire Naturelle, 45 bis rue de Buffon, Paris 5e, France (F. '30). *Trechus, Anophthalmes.*
'36. Jen, Ming-Tao, Div. of Entomology, University Farm, St. Paul, Minn.
'10. Jennings, H. R., High School of Com., Hayes and Van Ness Ave., San Francisco, Calif. *Diptera.*
'15. Jewett, H. H., Agri. Exp. Sta., Lexington, Ky. *Tobacco and Forage Crop Insects.*
Ch. JOHANNSEN, O. A., 203 Parkway, Ithaca, N. Y. (F. '14; H. F. '39). *Diptera.*
'25. Johnson, Frank, 420 Lexington Ave., New York, N. Y.
'39. Johnson, John W., 112 Agricultural Hall, Univ. of California, Berkeley, Calif. *Saturniidae.*
'26. Johnston, H. G., P. O. Box 751, Phoenix, Ariz. *Miridae, Hemiptera.*
'27. Jones, Elmer T., 1204 Fremont, Manhattan, Kans. *Hessian Fly.*
Ch. Jones, Frank M., 2000 Riverview Ave., Wilmington, Del. *Psychidae.*
'35. Jones, Harold C., Mount Berry, Ga. *Membracidae.*
'39. Jones, J. R. J. Llewellyn, "Arranmore," R. M. D. No. 1, Cobble Hill, British Columbia, Canada. *Ecology of Lepidopterous larvae.*

'34. Kagy, J. Franklin, Citrus Exp. Station, Riverside, Calif. *Insect Toxicology.*
'16. Kahl, Hugo, Carnegie Museum, Pittsburgh, Pa. *Odonata.*
'26. Kamal, Mohammed, Parasite Laboratory, Cotton Research B., Giza, Egypt. *Cotton Insects.*
'34. Kearns, Clyde W., Illinois Natural History Survey, Urbana, Ill. *Insecticides.*
'29. Keck, Chester B., Box 340, Honolulu, Hawaii. *Ecology.*
'14. KENNEDY, C. H., Dept. Zool. and Entomology, Ohio State Univ., Columbus, Ohio (F. '27). *Odonata.*

'36. Kessel, Berta B., 2326 Russell, Berkeley, Calif.
Ch. Kincaid, Trevor, Univ. Wash., Seattle, Washington. *Psychodidae, Dystiscidae.*
'12. KING, J. L., Box 150, Moorestown, New Jersey, (F. '32). *Biological Control.*
'23. KING, KENNETH M., Dominion Entomological Laboratory, Saskatoon, Sask., Canada. (F. '38). *Elateridae larvae, Noctuidae.*
'28. KING, WILLARD V., Box 491, Orlando, Florida. (F. '38). *Culicidae.*
'18. KINSEY, ALFRED C., Indiana Univ., Bloomington, Ind. (F. '28). *Cynipidae.*
'28. Kislanko, J. P., Box 88, Wiggins, Miss. *Aphididae.*
'32. Klein, Adolph, 370 Lexington Ave., New York, N. Y. *Odonata.*
'38. Klots, Alexander B., Biology Dept., 17 Lexington Ave., New York, N. Y. *Lepidoptera.*
'11. KNIGHT, H. H., Dept. Zool., St. College, Ames, Iowa. (F. '28). *Hemiptera, Miridae.*
'40. Knigin, Tamarath, 617 Ontario St., S. E., Minneapolis, Minn.
'24. Knowlton, George F., Agri. Exp. Sta., Logan, Utah. *Aphididae.*
'32. Knull, Mrs. Dorothy, 330 E. Dunedin Rd., Columbus, Ohio. *Erythroneura.*
'34. Knull, Josef N., Dept. Zool. & Ent., Ohio State Univ., Columbus, Ohio. *Cleridae, Elateridae, Buprestidae, Cerambycidae.*
'37. Knutson, Herbert C., Dept. Biology, Southern Methodist Univ., Dallas, Texas. *Noctuidae.*
'17. Kraatz, Walter C., Univ. Akron, Akron, Ohio.
'34. Krombein, Karl Von Vorse, 22 Meadow View Place, Buffalo, N. Y. *Aculeate Hymenoptera.*
'36. Kulash, Walter M., P. O. Box 99, Haydenville, Mass. *Diptera.*
'23. Kuwayama, Satoru, Hokkaido Agri. Exp. Sta., Kotoni, Sapporo, Japan. *Neuroptera, Trichoptera, Psyllidae.*

'28. Lamiman, J. F., Univ. Calif., Davis, Calif. *Acarina.*
'30. Landis, B. J., Box 30, Puyallup, Washington. *Biological Control.*
'25. Langford, George S., Dept. Ent., Univ. Maryland, College Park, Md. *Economic Entomology.*
'17. Langston, James M., A. & M. College, Miss. *Phyllophaga.*
'37. La Rivers, Ira, Box 1493, Reno, Nevada. *Odonata, Psychodidae.*
'14. Larrimer, W. H., U. S. D. A. Forest Service, Washington, D. C. *Cicadellidae.*
'38. Larson, N. P., Ent.-Zool. Dept., South Dakota State College, Brookings, S. D. *Physiology.*
'37. Lassman, G. W., Apartado No. 549, Mexico, D. F., Mexico. *Culicidae.*
'13. Lathrop, F. H., Agri. Exp. Station, Orono, Maine. *Cicadellidae.*
'23. Lauderdale, J. L. E., Box 368, Yuma, Arizona.
'17. LAWSON, PAUL B., 2244 New Hampshire St., Lawrence, Kans. (F. '31). *Cicadellidae.*
'39. Leech, H. B., P. O. Box 308, Vernon, British Columbia, Canada. *Coleoptera.*
'12. Leiby, R. W., Comstock Hall, Cornell Univ., Ithaca, N. Y. *Embryology.*
'38. Leonard, Justin W., Hunt Creek Exp. Sta., P. O. Box 5, Lewiston, Mich. *Aquatic Insects.*
'28. Leonard, Mortimer D., care of Advertising Dept., The Dupont Co., Wilmington, Del. *Aphididae.*
'34. Le Veque, Norma, 1017 Maxwell Ave., Boulder, Colo. *Apoidea.*
'31. Lewis, Ralph H., 2801 Adams Mill Road, Washington, D. C. *Thysanoptera.*
'35. Li, Feng-Swen, care of Wang Sin Mao, Yun Shi Station, Canton-Hankow Railroad, Hunan, China. *Culicidae.*
'33. Lilly, John H., King Hall, Univ. of Wisc., Madison, Wis. *Coleophoridae.*
'39. Lincoln, Charles, Farm Bureau Office, Oswego, N. Y. *Forage Crop Insects.*
'34. Lindgren, David L., Univ. of Calif., Citrus Exp. Sta., Riverside, Calif. *Toxicology.*
'39. Lindquist, Arthur W., Nice, Lake Co., Calif. *Chironomidae.*
'17. Lindsey, A. W., Box 612, Granville, Ohio. *Hesperioidea.*
'32. Ling, Shao-wen, Dept. Biol., Univ. Amoy, Amoy, China. *Trichoptera.*
'33. *Linsley, E. Gorton, 112 Agricultural Hall, University of California, Berkeley, Calif. *Cerambycidae of World, Coleoptera of N. Am.*
'25. LIST, GEO. M., Agri. College, Fort Collins, Colo. (F. '32). *Cimicidae.*

'30. Littell, Mrs. Dorothy D., 9213 Vantine St., Wilkinsburg Bra., Pittsburgh, Pa.
'34. Liu, Chi-ying, Kwangsi Agri. Exp. Station, Liuchow, Kwangsi, China. *Siphonaptera.*
'30. Livingston, E. M., 4425 Bienville Ave., New Orleans, La. *Thysanoptera, Orthoptera.*
Ch. Lloyd, J. T., 300 West Court St., Cincinnati, Ohio. *Trichoptera.*
'31. Lloyd, Llewellyn, University, Leeds, England.
'19. Lobdell, Mrs. Gladys H., Lakeland, Fla. *Coccidae.*
'30. Loftin, U. C., Bureau Entomology & Pl. Q., Washington, D. C.
'38. Lowrie, Raymond E., 48 State St., P. O. Box 114, New Bedford, Mass.
'38. Ludwig, Daniel, Dept. of Biology, N. Y. Univ., 181st St. and Univ. Ave., New York, N. Y. *Physiology.*
'13. Luginbill, Philip, Box 495, Lafayette, Ind. *Phyllophaga.*
'34. Lund, Horace O., Division of Biological Science, Univ. of Georgia, Athens, Georgia. *Culicidae.*
Ch. Lutz, Frank E., 13 N. Central Ave., Ramsey, N. J. (F. '17). *Bees.*
'40. Lyman, F. Earle, Dept. of Zoology, Univ. of Michigan, Ann Arbor, Mich. *Aquatic Insects, Ephemeroptera.*
'31. Lyle, Clay, State College, Miss. *Crustacea.*

'28. MacAndrews, A. H., College of Forestry, Syracuse, N. Y. *Scolytidae.*
'36. MacCreary, Donald, Del. Agri. Exp. Sta., Newark, Delaware. *Tabanidae, Culicidae.*
'32. MacLeod, Guy F., Dept. of Ent., Univ. of California, Berkeley, Calif. *Physiology.*
'40. MacSwain, J. W., 2918 Piedmont Ave., Berkeley, Calif.
'20. McBride, O. C., Box 340, Honolulu, Hawaii. *Insecticides.*
'29. McClure, H. Elliott, Lewis, Iowa. *Ecology.*
'17. McCracken, Isabel, Box 1545, Stanford University, Calif. (F. '39). *Apoidea.*
'10. McDaniel, Eugenia, Agri. College, East Lansing, Mich. *Coccidae, Orthoptera.*
'30. McGovran, E. R., Bureau of Ent. & Plant Quar., Nat. Agr. Res. Center, Beltsville, Md. *Toxicology.*
'25. McGregor, E. A., Box 70, Whittier, Calif. (F. '38). *Tetranychidae.*
'11. McIndoo, N. E., 7225 Blair Rd., Takoma Park, Washington, D. C. (F. '34). *Insect Physiology.*
'32. McKinstry, Arthur Porter, 932nd Co., C. C. C., Naches, Washington. *Microvelia.*
'35. Ma, Hsien-chen, Dept. of Biology, Lingnan Univ., Canton, China. *Medical Entomology.*
'32. Madden, A. H., Box 549, Quincy, Florida. *Economic Entomology.*
'34. Madden, Ruth A., 324 Stutsman St., Council Bluffs, Iowa.
'17. Maheux, Georges, Dept. Agri., Parliament Bldg., Quebec, Canada. *Forest Insects.*
'36. Malcomson, R. O., 1105 West Illinois St., Urbana, Illinois. *Mallophaga.*
'38. Mally, Fred. W., 1627 W. Huisache Ave., San Antonio, Texas. *Cotton Insects.*
'40. Mangrum, James F., Lincoln Memorial University, Harrogate, Tenn.
'33. Manis, Hubert C., Ent. Branch Exp. Stat., Parma, Idaho. *Onion, Potato Insects.*
'21. *Mank, Edith Webster, 12 Reservoir St., Lawrence, Mass. *Coleoptera.*
'21. Mank, Helen G., 12 Reservoir St., Lawrence, Mass.
'13. *Mann, Wm. M., Nat. Zool. Park, Washington, D. C. (F. '37). *Formicidae.*
'23. Manter, Jerauld A., Agri. College, Storrs, Conn. *Economic Entomology.*
'37. Manzelli, Manlio, 258 Netherwood Ave., Plainfield, N. J. *Hymenoptera.*
'35. *Maple, John D., P. O. Box 47, Yokohama, Japan. *Physiology.*
'38. March, Ralph B., 303 Entomology Bldg., Univ. of Illinois, Urbana, Ill.
'22. Marcovitch, S., University Farm, Knoxville, Tenn. *Insecticides.*
'37. Markos, Basil G., 485 Central Ave., Dover, New Hampshire. *Buprestidae.*
Ch. Marlatt, C. L., 1521 16th St., N. W., Washington, D. C. (F. '07). *Coccidae.*
Ch. Marshall, W. S., 139 E. Gilman St., Madison, Wis. (F. '17). *Morphology.*
'25. Martin, Chas. H., Box 254, Marietta, Ohio. *Ecology.*

'37. Martin, Rosemary D. C., 24 Hawthorne Ave., Toronto, Ontario, Canada. *Odonata.*
'34. Martorell, Luis F., P. O. Box 614, Rio Piedras, Puerto Rico. *Sugar Cane, Forest Insects.*
'38. Marvin, Philip H., Div. of Ent., Univ. Farm, St. Paul, Minn. *Biology of Melittobia.*
'21. Mason, Arthur C., Box 340, Honolulu, Hawaii. *Thysanoptera.*
'30. Mason, Horatio C., 151 West 11th Ave., Columbus, Ohio. *Tomato Fruitworm.*
Ch. MATHESON, ROBT., Cornell Univ., Ithaca, N. Y. (F. '28). *Ixodoidea, Culicidae.*
'34. Mattingly, Father H. E., St. Charles Coll., P. O. Box 303, Columbus, Ohio. *Coleoptera.*
'34. Maxson, Asa C., P. O. Box 46, Longmont, Colo. *Aphidae.*
'34. Maxwell, K. E., Div. of Entomology, Citrus Experiment Station, Riverside, Calif. *Citrus Insects.*
'36. Mead, Albert R., Dept. of Entomology, Cornell Univ., Ithaca, N. Y. *Chrysomelidae.*
'37. Medler, John T., Div. of Entomology, University Farm, St. Paul, Minn. *Cicadellidae.*
'25. Meiners, Edwin, Rm. 238, 6651 Enright, St. Louis, Mo. *Lepidoptera.*
'32. Melampy, R. M., Louisiana Agri. Exp. Station, University, La. *Physiology.*
Ch. MELANDER, A. L., City College of New York, New York, N. Y. (F. '14). *Diptera.*
'27. Melvin, Roy, Box 487, Menard, Texas. *Physiology.*
'39. Mendenhall, Eugene W., 97 Brighton Road, Columbus, Ohio.
'33. Menusan, Henry, Jr., R. F. D. No. 2, Gilboa, N. Y. *Physiology, Ecology.*
'32. Merino, Gonzalo, Bureau Plant Industry, Manila, P. I. *Cicadellidae.*
'23. Merrill, G. B., Plant Board, Seagle Bldg., Gainesville, Fla. *Coccidae, Aleyrodidae.*
'12. METCALF, C. L., Nat. Hist. Bldg., Univ. Ill., Urbana, Ill. (F. '20). *Syrphidae.*
'39. Metcalf, Robert L., 704 Pennsylvania Ave., Urbana, Illinois. *Toxicology.*
'09. METCALF, Z. P., State College Station, Raleigh, North Carolina. (F. '34). *Homoptera.*
'35. Michelbacher, A. E., 112 Agri. Hall, Univ. of Calif., Berkeley, Calif. *Symphyla, Apoidea.*
'37. Michener, Charles D., 418 N. Hudson, Pasadena, Calif. *Apoidea.*
'17. MICKEL, CLARENCE E., Div. Ent., Univ. Farm, St. Paul, Minn. (F. '35). *Mutillidae.*
'36. Miles, Virgil I., P. O. Box 547, Savannah, Ga. *Culicidae.*
'36. Miller, Albert, 117-36 225th St., St. Albin, L.I., N.Y. *Pyralididae.*
'31. Miller, Albert C., Box 2038, Pittsburgh, Pa. *Membracidae.*
'28. Miller, D. F., Ohio State Univ., Dept. Zool., Columbus, Ohio. *Diptera.*
'30. Miller, Forrest W., Biology Dept., Hartwick College, Oneonta, N. Y. *Aphididae.*
'37. Milliron, Herbert E., Div. of Entomology, University Farm, St. Paul, Minn. *Chalcidoidea, Bombidae.*
'29. MILLS, HARLOW B., Dept. of Ent., Montana State College, Bozeman, Mont. (F. '37). *Collembola.*
'37. Milne, Lorus J., Randolph-Macon Woman's College, Lynchburg, Va. *Trichoptera.*
'25. Milum, Vern G., 104 Exp. Zool. Lab., Univ. of Illinois, Champaign, Ill. *Apiculture.*
'26. MINNICH, D. E., Dept. Zool., Univ. of Minnesota, Minneapolis, Minn. (F. '39). *Behavior.*
'35. Minkewich, Stanislaw, Dept. Ent. Govt. Inst. for Agri. Research, Pulawy, Poland. *Tortricidae.*
'38. Miroyiannis, Stanley D., Dept. of Biology, Northeastern Univ., Boston, Mass. *Histology.*
'39. Mitchell, Robert T., 410 W. Union St., West Chester, Penn. *Ichneumonidae and Braconidae.*
'21. MITCHELL, T. B., State College, Raleigh, N. Car. (F. '37). *Apoidea, Megachile.*
'30. Miwa, Yushiro, Dept. Agri., Gov. Research Institute, Taihoku, Formosa. *Elateridae.*

'21. *Moffatt, Elizabeth M., 328½ N. Rampart, Los Angeles, Calif. *Araneida.*
'39. Monk, J. W., Box 535, Fabens, Texas. *Diptera.*
'22. MONTGOMERY, B. ELWOOD, Dept. Ent., Purdue Univ., Lafayette, Ind. (F. '31). *Odonata.*
'39. Moore, Geo. A., 359 Querbes Ave., Outremont, Quebec, Canada. *Hemiptera.*
'34. Moore, Joseph B., R. R. No. 2, Western Ave., Wenatchee, Wash. *Insecticides.*
'39. Moore, Warren, Bon Air, Va. *Dermestidae.*
'08. MORGAN, ANN H., Mt. Holyoke College, South Hadley, Mass. (F. '37). *Ephemeridae.*
Ch. Morgan, H. A., University Library, Univ. of Tennessee, Knoxville, Tenn.
'27. Morgan, W. P., R. R. No. 6, Box 333D, Indianapolis, Ind. *Dermaptera.*
Ch. MORRILL, A. W., 1612 W. Glenoaks Blvd., Glendale, Calif. (F. '39). *Biological Control.*
'12. MORRISON, HAROLD, Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '28). *Coccidae.*
'08. MOSHER, EDNA, Adelphi College, Garden City, N. Y. (F. '20). *Lepidoptera.*
'20. Mote, Don C., State Agri. College, Corvallis, Oregon. *Economic Entomology.*
'29. MOULTON, DUDLEY, 35 Elwood St., Redwood City, Calif. (F. '31). *Thysanoptera.*
'15. MUSEBECK, C. F. W., Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '34). *Braconidae, Bethylidae.*
'38. Mullen, James A., 135 Siwanoy Blvd., Tuckahoe, N. Y. *Isoptera.*
'36. Mulrennan, J. A., Escambia County Health Dept., Pensacola, Fla. *Culicidae.*
'30. Mundell, R. C., Care Thomas Cook & Sons, Bankers, 4 Kashmir Gate, Delhi, India. *Parasitic Hymenoptera.*
'27. Munro, J. A., State College Station, Fargo, N. Dak. *Orthoptera, Diptera.*
'37. Munson, Sam C., Bur. Ent. & P. Q., Research Center, Beltsville, Md. *Insect physiology.*
'35. *Murray, William D., Div. Ent., Univ. of Minnesota, St. Paul, Minn. *Sphecidae.*
'28. Musgrave, Anthony, Australian Museum, College St., Sydney, New South Wales, Australia. *Nycteribiidae.*
'27. Musgrave, Paul, Box 426, Huntington, W. Va. *Dryopidae.*
'15. Muttkowski, R. A., Univ. of Detroit, Detroit, Mich. *Physiology, Ecology,*
'35. Nagel, R. H., Forest Insect Laboratory, Bur. Ent. and Plant Quarantine. Coeur d'Alene, Idaho. *Phyllophaga.*
Ch. NEEDHAM, J. G., 6 Needham Place, Ithaca, N. Y. (F. '07; H. F. '35). *Odonata, Ephemerida.*
'21. Neiswander, C. R., Ohio Agri. Exp. Sta., Wooster, Ohio. *Insects of ornamentals.*
'28. Neiswander, R. B., Agri. Exp. Sta., Wooster, Ohio. *Fruit Insects.*
'07. Nelson, J. A., Gambier, Ohio. *Development of honeybee.*
'39. Nesbitt, Herbert H. J., 34 Lakeside Ave., Ottawa, Ontario, Canada. *Morphology.*
Ch. Ness, Henry, 821 Kellogg Ave., Ames, Iowa. *Economic Entomology.*
'36. Nettleton, 2nd, Geo. E., Amity Road, Woodbridge, Conn. *Braconidae.*
'34. Nevin, F. Reese, 316 Columbia St., Ithaca, N. Y. *Morphology of Acarina.*
Ch. Newcomer, E. J., Box 1291, Yakima, Wash. *Fruit Insects.*
'07. Newell, Wilmon, 504 East Church St., Gainesville, Fla. *Economic Entomology.*
'15. Newman, Geo. B., 246 E. Hamilton Ave., State College, Pa. *Insect Histology.*
'28. Newton, Richard C., 121 East Story St., Bozeman, Mont. *Alfalfa weevil.*
'38. Nicholson, H. Page, Div. of Ent., Univ. Farm, St. Paul, Minn. *Simuliidae.*
'31. Nickels, C. B., Box 209, Bureau of Entomology, Brownwood, Texas. *Pecan Insects.*
'22. Noble, W. B., Bur. of Ent. and P. Q., Box 1857, Sacramento, Calif. *Hessian Fly.*
'38. Noland, Lowell E., Biology Bldg., Univ. of Wisconsin, Madison, Wis.
'17. *Notman, Howard, Circle Rd., Dougan Hills, Staten Island, N. Y. *Carabidae, Staphylinidae.*
'37. Nye, William P., 31 Federal Ave., Logan, Utah. *Forest Insects.*

'31. O'Byrne, Harold I., 663 W. Lockwood Ave., Webster Groves, Mo. *Ecology, Lepidoptera.*
'08. O'KANE, WALTER C., Durham, N. H. (F. '24).
'29. Oman, Paul W., Div. of Insects, National Museum, Washington, D. C. *Homoptera.*
'37. O'Neill, William J., Tree Fruit Branch Exp. Stat., Box 596, Wenatchee, Wash. *Fruit Insects.*
'34. Oosthuizen, M. J., School of Agriculture, Potchefstroom, South Africa. *Stored Grain Insects.*
Ch. OSBORN, HERBERT, Ohio State Univ., Columbus, Ohio (F. '07; H. F. '28). *Homoptera, Cicadellidae.*
'08. Osborn, H. T., 1952 Concord Road, Columbus, Ohio. *Insects and Plant Diseases.*
Ch. OSBURN, R. C., Ohio State Univ., Columbus, Ohio (F. '17). *Syrphidae.*
'20. Otanes, Faustino Q., Bureau of Plant Industry, Manila, Philippine Islands. *Coccidae.*
'36. Owen, Wm. Bert, Dept. of Zool., Univ. of Wyoming, Laramie, Wyo. *Culicidae.*
'25. Ozburn, Reg. H., Ontario Agri. College, Guelph, Ontario, Canada. *Insect Histology.*

'15. Packard, Clyde M., Bureau of Ent. and Plant Quarantine, Washington, D. C. *Cereal and Forage Insects.*
'18. Painter, H. R., Box 495, Lafayette, Indiana. *Phyllophaga.*
'19. PAINTER, R. H., Dept. Ent., K. S. C., Manhattan, Kans. (F. '35). *Diptera, Bombyliidae.*
'23. Pallister, John, 3754 Independence Road, Cleveland, Ohio. *Coleoptera.*
'39. Palm, Charles E., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Forage Crop Insects.*
'37. Palmer, Boyd B., Polytechnic Institute, San German, Puerto Rico. *Trichoptera.*
'27. PALMER, MIRIAM A., Dept. Ent., Agri. College, Fort Collins, Colo. (F. '37). *Aphidae.*
'33. Parish, H. E., Box 487, Menard, Texas.
'27. Park, Orlando, Dept. Zool., Northwestern Univ., Evanston, Ill. *Pselaphidae.*
'39. Parker, Barbara M., 416 E. 47th Terrace, Kansas City, Mo.
'24. Parker, Donald E., 8 Whippany Road, Morristown, N. J. *Insect Vectors and Elm Disease.*
'25. Parker, H. L., Dept. of Agr., Bur. of Ent. and Plant Quarantine, Washington, D. C. *Parasitic Hymenoptera.*
'18. Parker, J. B., Catholic University of America, Washington, D. C. *Bembicidae.*
'37. Parker, J. R., Bureau of Ent. and Plant Quarantine, Bozeman, Mont. *Orthoptera.*
'24. Parker, R. L., Dept. Ent., K. S. C., Manhattan, Kans. *Apiculture.*
'34. Parks, Hal B., Austin College, Nacogdoches, Texas. *Diptera, Hymenoptera.*
'16. Parks, H. B., Route 1, Box 368, San Antonio, Texas. *Apiculture.*
'18. Parks, T. H., Dept. Ent., Ohio State Univ., Columbus, Ohio.
'24. Parman, D. C., Box 509, Uvalde, Texas. *Diptera.*
Ch. PARROTT, P. J., Agri. Exp. Sta., Geneva, N. Y. (F. '14).
'12. Parshley, H. M., Dept. Zool., Smith College, Northampton, Mass. *Heteroptera.*
'32. Parsons, Carl T., 205 West 57th St., New York City, N. Y.
'34. Parten, Herbert L., Div. of Ent., Univ. Farm, St. Paul, Minn. *Greenhouse Insects.*
'32. Passos, Cyril F. dos, Washington Corners, Mendham, N. J. *Lepidoptera.*
Ch. *PATCH, EDITH M., Agri. Exp. Sta., Orono, Maine (F. '14). *Aphididae.*
'35. Paulian, Renaud, Laboratoire d'Entomologie, Museum d'Histoire Naturelle, 45 bis Rue de Buffon, Paris V, France. *Scarabaeidae, Corylophidae.*
'35. Paullus, Harold J., Crystal City, Mo.
'23. Payne, Nellie M., Care of American Cyanamide Co., Boston Post Road, Stamford, Conn. *Physiology.*

'20. Peairs, L. M., Morgantown, W. Va.
'34. Pechuman, La Verne L., Barry Lime Sulphur Co., Lyndonville, N. Y. *Tabanidae.*
'37. Pelton, John Z., 94 E. Tulane Road, Columbus, Ohio. *Aquatic Insects.*
'35. Penner, Lawrence R., Dept. Zoology, Univ. of Minnesota, Minneapolis, Minn. *Araeopidae.*
'30. Pepper, Bailey B., Dept. Ent., Agri. Exp. Sta., New Brunswick, N. J. *Biological Control.*
'32. Pepper, James Hubert, Montana State College, Bozeman, Mont. *Insecticides.*
'29. Peters, Harold T., Dept. of Ent., University Farm, St. Paul, Minn. *Siphonaptera.*
'39. Peterson, Allan G., Div. Ent., University Farm, St. Paul, Minn. *Potato Insects.*
'11. PETERSON, ALVAH, Dept. Ent., Ohio State Univ., Columbus, Ohio (F. '28). *Biological Control.*
'37. Peterson, Lloyd O. T., Indian Head, Saskatchewan, Canada.
'39. Petrakis, Manuel M., State Natural History Survey, Urbana, Ill. *Dermestidae.*
'40. Pettit, Lincoln C., Roberts Hall, Box 45, Ithaca, N. Y.
Ch. PETTIT, R. H., Dept. Ent., Michigan State College, East Lansing, Mich. (F. '39). *Coccidae.*
'07. PETRUNKEVITCH, ALEXANDER, Yale Univ., New Haven, Conn. (F. '27). *Arachnida.*
'21. PHILLIPS, E. F., Cornell Univ., Ithaca, N. Y. (F. '29). *Apiculture.*
'38. Phillips, Maurice E., Hanshow Road, Ithaca, N. Y.
'12. Phillips, W. J., Box 255, Charlottsville, Va. *Harmolita.*
'37. Phillips, W. Levi, 985 South Third East, Salt Lake City, Utah. *Lepidoptera.*
Ch. PIERCE, W. DWIGHT, Los Angeles County Museum, Exposition Park, Los Angeles, Calif. (F. '30). *Rhynchophora.*
'35. Pinkus, L. F., R. 5, Box 700, Webster Groves, Mo. *Arachnida.*
'39. Plumb, George H., Agri. Exp. Station, New Haven, Conn. *Anoplura.*
'28. Plummer, C. C., Calzada Tacuba 295, Colonia Anahuac, Mexico, D. F., Mexico. *Membracidae.*
'18. Poos, Fred W., 3225 Albemarle St., Cherrydale, Va.
'23. Porter, B. A., Bureau Ent. and Plant Quarantine, Washington, D. C. *Fruit Insects.*
'34. Post, R. L., Dept. of Ent., Oregon State College, Corvallis, Oregon. *Staphylinidae.*
'26. Potts, Samuel F., 56 Hillhouse Ave., New Haven, Conn. *Toxicology, Physiology.*
'37. Powell, Dwight, 1106 S. Locust St., Champaign, Ill. *Insecticides.*
'25. Powell, Eugene F., 306 Bessey Hall, Univ. Nebraska, Lincoln, Nebr. *Chrysomelinae.*
'36. Pratt, Harry D., Div. of Entomology, Univ. Farm, St. Paul, Minn. *Ichneumonidae.*
'16. Price, W. A., Univ. of Kentucky, Lexington, Ky. *Economic Entomology.*
'32. *Pritchard, A. Earl, Div. of Ent., Univ. Farm, St. Paul, Minn. *Asilidae.*
'28. Procter, Wm., Bar Harbor, Maine. *Insects of Mt. Desert Region.*
'33. Putman, W. L., Dom. Ent. Lab., Vineland Station, Ontario, Canada. *Chrysopidae.*

'36. Quarterman, Kenneth D., Box 989, Gulfport, Miss. *Cimicidae.*

'14. RAU, PHIL, 549 E. Argonne Drive, Kirkwood, Mo. (F. '27). *Hymenoptera, Behavior.*
'23. READIO, PHILIP A., Dept. of Ent., Cornell Univ., Ithaca, N. Y. (F. '37). *Reduviidae.*
'23. Reed, W. D., 17 North Boulevard, Richmond, Va. *Tobacco Insects.*
'30. Rees, Don M., Univ. of Utah, Salt Lake City, Utah. *Culicidae.*
'23. Reeves, Jos. A., 416 Federal Annex, Atlanta, Ga. *Chrysomelidae, Fulgoridae.*
'08. Regan, W. S., 1701 West Yakima Ave., Yakima, Wash.
Ch. REHN, J. A. G., Acad. Nat. Sciences, Logan Square, Philadelphia, Pa. (F. '14). *Dermaptera, Orthoptera.*

'34. Rice, Paul L., Alma College, Alma, Mich. *Chalcidoidea.*
'30. RICHARDS, A. GLENN, JR., Zoological Laboratories, Univ. of Pennsylvania, 38th St. and Woodland Ave., Philadelphia, Pa. (F. '38). *Noctuidae.*
'14. RICHARDSON, CHAS. H., Dept. Ent., Iowa State College, Ames, Iowa (F. '31). *Physiology.*
'29. Richardson, H. H., Beltsville Research Center, Beltsville, Md. *Physiology.*
'28. Richmond, Edward A., Agri. Exp. Sta. Bldg., State College, Pa. *Hydrophilidae.*
'39. Riedel, F. Atherton, 1340 Corona St., Denver, Colo.
'39. Riegel, Garland T., 304 Entomology Bldg., Univ. of Illinois, Urbana, Ill. *Braconidae.*
'22. Ries, Donald T., Starved Rock State Park, Utica, Ill. *Cephidae, Siricidae.*
'29. Riley, Merrill K., Box 57, Kaneohe, Hawaii. *Coccidae.*
Ch. RILEY, WM. A., Div. Ent., Univ. Farm, St. Paul, Minn. (F. '14). *Parasitology.*
'39. Rings, Roy W., 70 S. Burgess Ave., Columbus, Ohio. *Morphology.*
'33. Ritcher, Paul O., Agri. Exp. Station, Lexington, Ky. *Phyllophaga.*
'36. Ritchie, C. L., 422 Federal Office Bldg., Seattle, Wash.
'25. Rivnay, Ezekiel, Agri. Exp. Sta., Rehoboth, Palestine. *Thysanoptera.*
'39. Roark, R. C., Bur. Ent. and P. Q., U. S. D. A., Washington, D. C. *Insecticides.*
'31. Roberts, J. Harvey, Box 376, University Station, University, La. *Trichoptera.*
'28. Roberts, R. A., 820 Insurance Exchange Bldg., Denver, Colo. *Mantidae.*
'15. Robinson, J. M., Box 671, Auburn, Alabama. *Coccidae, Coleoptera.*
'26. ROBINSON, WM., Burnt Mills Hills, Silver Spring, Md. (F. '39). *Physiology.*
'13. Rockwood, L. P., Forest Grove, Oregon. *Noctuidae, Orthoptera.*
'31. Rodeck, Hugo G., Univ. Colorado Museum, Boulder, Colo. *Nomada.*
'15. Rogers, J. Speed, Box 2666, Univ. Station, Gainesville, Fla. *Tipulidae.*
'27. ROHWER, S. A., Bur. Ent. and P. Q., Washington, D. C. (F. '29). *Hymenoptera.*
'14. Rosenfeld, A. H., Boite Postale 763, Cairo, Egypt. *Sugar Cane Insects.*
'25. Rosewall, O. W., Dept. Ent., Louisiana State Univ., University, La. *Coleoptera, Pentatomidae.*
'39. Ross, Edward S., Dept. Ent., Calif. Acad. Sci., San Francisco, Calif. *Histeridae, Embioptera.*
'31. ROSS, HERBERT H., State Nat. Hist. Survey, Urbana, Ill. (F. '37). *Tenthredinoidea.*
'19. Ross, Wm. A., Vineland Station, Ontario, Canada. *Aphididae.*
'36. Rozeboom, Lloyd Eugene, School of Hygiene and Public Health, 615 N. Wolf St., Baltimore, Md. *Culicidae.*
'14. Ruckes, Herbert, 167-11 33rd Ave., Flushing, L. I., New York. *Pentatomidae.*
'39. Rude, Clifford S., 234 N. Washington, Gainesville, Fla. *Ixodidae.*
Ch. RUGGLES, A. G., University Farm, St. Paul, Minn. (F. '35).

'33. *Sabrosky, Curtis W., Dept. of Ent., Michigan State College, East Lansing, Mich. *Chloropidae.*
'38. Salisbury, Murl B., Genl. Del., Fisher, Ill. *Chrysomelid larvae.*
'29. Sakimura, Kay, Pineapple Exp. Station, Honolulu, Hawaii. *Thysanoptera.*
'23. Salman, Kenneth A., 335 Giannini Hall, Univ. California, Berkeley, Calif. *Forest Insects.*
'37. Sampson, William W., 156 S. 14th St., Richmond, Calif. *Aphididae, Aleurodidae.*
Ch. SANDERS, J. G., 604 Second Ave., Parkesburg, Pa. (F. '20).
'31. Sanderson, Milton W., Dept. of Ent., Univ. of Arkansas, Fayetteville, Ark. *Coleoptera.*
'33. Sandhouse, Grace A., Room 378, U. S. National Museum, Washington, D. C. *Aculeate Hymenoptera.*
'31. Sargent, Wm. D., Biology Dept., The City College, 17 Lexington Ave., New York, N. Y. *Odonata, Ephemerida.*
'07. SATTERTHWAIT, A. F., 806 Ohio St., Urbana, Ill. (F. '30). *Calendra.*
'29. Scaramuzza, L. C., Central Baragua, Prov. of Camaguay, Cuba. *Sugar Cane Insects.*

'30. Schaefer, Paul E., Dept. Ent., Ohio State Univ., Columbus, Ohio. *Morphology.*
'25. Schear, E. W. E., 107 W. Park St., Westerville, Ohio. *Hemiptera, Diptera, Hymenoptera.*
'30. Schlosberg, Morris, 1920 Parkwood Ave., Toledo, Ohio. *Lepidoptera.*
'29. Schmidt, Carl T., Box 3166, Honolulu, Hawaii. *Ecology.*
'33. Schmidt, Helen D. O'Neil, Box 3166, Honolulu, Hawaii. *Trichoptera.*
'20. Schmieder, Rudolf G., Zool. Lab., Univ. of Pennsylvania, Philadelphia, Pa.
'32. Schmitt, John B., 411 White Horse Ave., Trenton, N. J. *Morphology.*
'34. Schmitt, T. J., Jr., 820 Insurance Exchange Bldg., Denver, Colo. *Scolytidae.*
Ch. Schoene, W. J., Agri. Exp. Sta., Blacksburg, Va.
'36. Schoof, Herbert F., 304 Entomology Bldg., Univ. of Illinois, Urbana, Ill. *Chrysomelidae.*
'29. Schroeder, H. O., Halstead, Kans. *Ixodoidea, Argasidae.*
'37. Schroeder, Philip M., 1979 Ashland Ave., St. Paul, Minn. *Forest Insects.*
'32. Schumaker, George K., 1949 W. Main St., Norristown, Pa. *Coleoptera.*
'26. SCHWARDT, H. H., Dept. Ent., Cornell Univ., Ithaca, N. Y. (F. '35). *Tabanidae.*
'26. SCHWARZ, HERBERT F., Am. Mus. Nat. Hist., 77th St. and Cent. Park West, New York City, N. Y. (F. '37). *Apoidea.*
'28. Scotland, Minnie B., 42 Continental Ave., Cohoes, N. Y. *Lemna Insects.*
'25. Scullen, H. A., 325 S. 13th St., Corvallis, Oregon. *Cerceridae.*
'23. Seamans, H. L., Dom. Ent. Lab., Lethbridge, Alberta, Canada. *Muscoidea.*
'36. Seevers, Charles, Central Y. M. C. A. College, 19 South LaSalle St., Chicago, Ill. *Aleocharinae.*
'22. Sellers, Wendell F., 56 Hillhouse Ave., New Haven, Conn. *Tachinidae.*
'38. Semans, F. Merrick., North Jackson, Ohio.
'29. Setty, L. R., Park College, Parkville, Mo. *Mecoptera, Bittacus.*
'08. SEVERIN, H. C., South Dakota State College, Brookings, S. D. (F. '39). *Orthoptera, Homoptera, Heteroptera.*
'37. Shadle, Albert R., Dept. Biology, Univ. of Buffalo, Buffalo, N. Y. *Coleoptera.*
'07. Shafer, Geo. D., 321 Melville Ave., Palo Alto, Calif. *Physiology.*
'18. *SHANNON, R. C., Caiza Postal 49, Rio de Janeiro, Brazil (F. '34). *Diptera.*
'35. Shaw, Frank R., Fernald Hall, Mass. State College, Amherst, Mass. *Mycetophilidae.*
'29. Shaw, John G., Hacienda de Santa Engracia, Santa Engracia, Tampa, Mexico.
Ch. SHELFORD, V. E., Vivarium Bldg., Wright and Healy Sts., Champaign, Ill. (F. '20). *Ecology.*
'22. SHEPARD, HAROLD H., Univ. Farm, St. Paul, Minn. (F. '39). *Hesperiidae.*
'17. Sherman, Franklin, Div. Ent., Clemson College, South Carolina. *Acrididae, Cermabycidae, Cicindelidae.*
'11. SHERMAN, JOHN D., JR., 132 Primrose Ave., Mt. Vernon, N. Y. (F. '39). *Dytiscidae.*
'34. Shields, S. E., Box 270, Ft. Pierce, Florida. *Culicoides.*
'38. Shipman, Horace J., Bur. Ent. & P. Q., Bozeman, Mont. *Mormon Cricket.*
'35. Shockley, Wilfred, Darby, Montana. *Cerambycidae.*
'28. Shropshire, Leslie H., Box 85, Des Plaines, Ill. *Economic Entomology.*
Ch. SHULL, A. FRANKLIN, 431 Highland Rd., Ann Arbor, Mich. (F. '39). *Aphididae.*
'29. Shull, W. E., Dept. Ent., Univ. Idaho, Moscow, Idaho. *Insect Blood.*
'15. SILVESTRI, FILIPPO, Scuola Superiore d'Agricoltura, Portici, Italy. (F. '20). *Thysanura, Protura, Termites, Myriapoda.*
'32. Silvey, J. K. Gwynn, Dept. of Biology, North Texas State Teacher's College, Denton, Texas. *Coleoptera.*
'35. Simizu, Tunehisa, Imp. Pl. Quar. Serv., Nagoya Custom House, Nagoya, Japan. *Bruchidae, Diptera.*
'29. Simmons, Perez, 712 Elizabeth St., Fresno, California. *Nitidulidae.*
'30. Simmons, S. W., P. O. Box 789, Panama City, Florida. *Medical Entomology.*
'39. Simonds, Wm. E., Agricultural Bldg., Embarcadero and Mission, San Francisco, Calif. *Elateridae.*

'25. Simons, Mrs. Carrie L., 4021 Alameda Drive, San Diego, Calif. *Insect Behavior.*
'30. *Simpson, Geddes W., Holmes Hall, Orono, Me. *Insects and Plant Diseases.*
'38. Singleton, J. M., 308 Customhouse, New Orleans, La. *Quarantines.*
'38. Skoog, Fred E., Bur. of Ent. & Pl. Quar., Bozeman, Montana. *Acrididae.*
'32. Smith, Carroll N., Box 115, Vineyard Haven, Mass. *Ixodidae.*
'32. Smith, Chas. E., Agricultural Center, University, La. *Truck Crop Insects.*
'35. Smith, Clyde F., Dept. of Entomology, Univ. of North Carolina, Raleigh, N. C. *Aphididae.*
'27. Smith, Floyd F., Research Center, Beltsville, Maryland. *Aphididae.*
'35. Smith, Frank K., 2228 Elizabeth St., Pueblo, Colo. *Aquatic Coleoptera.*
'37. Smith, Gordon E., 811 Manly Ave., Paris, Tenn. *Culicidae.*
'28. Smith, Herbert D., P. O. Box 150, Moorestown, N. J. *Ichneumonidae.*
'35. Smith, Howard W., Box 21, New Ipswich, New Hampshire. *Diptera.*
'39. Smith, Leslie M., Univ. Calif. Deciduous Fruit Stat., Rt. 1, Box 92, San Jose, Calif. *Economic Entomology.*
'37. Smith, Marion E., Fernald Hall, Mass. State College, Amherst, Mass. *Arctiidae.*
'19. SMITH, MARION R., Rm. 377, U. S. National Museum, Washington, D. C. (F. '38). *Formicidae.*
'39. Smith, Myron W., 113 West Rich St., Columbus, Ohio. *Curculionidae.*
'36. Smith, Ralph H., Univ. of Calif., 405 Hilgard Ave., Los Angeles, Calif. *Hemiptera.*
'14. SMITH, ROGER C., Dept. Ent., Kan. State College, Manhattan, Kansas (F. '31). *Neuroptera.*
'38. Smith, Septima C., Box 1446, University, Alabama.
'30. Smyth, E. Graywood, Hillcrest Ranch, Glen Ellen, Calif. *Cicindelidae.*
'18. Snapp, Oliver I., Box 527, Fort Valley, Georgia. *Rhynchophora.*
'39. Snipes, Benjamin T., Escola Superior de Agriculture e Veterinaria, Vicosa, Mines Gerais, Brazil.
'24. SNODGRASS, R. E., 3706 Thirteenth St., N. W., Washington, D. C. (F. '27). *Morphology.*
'36. Snyder, Fred M., 35–64 89th St., Jackson Heights, New York. *Muscoidea.*
'38. Sommerman, Kathryn M., Dept. of Ent. Univ. of Illinois, Urbana, Ill. *Corrodentia.*
'26. Sorenson, Chas. J., Agri. Exp. Sta., Logan, Utah. *Miridae.*
'14. *Spencer, G. J., Univ. Brit. Col., Vancouver, Brit. Col., Canada. *Trypetidae.*
'19. SPENCER, HERBERT, Subtropical Fruit Insects Laboratory, P. O. Box 112, Fort Pierce, Fla. (F. '37). *Hymenoptera.*
'31. Spieth, Herman T., College of City of New York, Convent Ave., and 139th St., New York, N. Y. *Ephemeroptera.*
Ch. Spooner, Chas. S., 1436 Seventh St., Charleston, Ill. *Fulgoridae.*
'29. Spruijt, F. J., Trap Rock Farm, Deerfield, Mass. *Formicidae.*
'39. Stafford, Eugene M., 1426 Q St., Sacramento, Calif. *Vegetable Insects.*
'10. Stafford, E. W., State College, Miss. *Mallophaga.*
'38. Stains, George S., Dept. Ent., Utah Agri. Coll., Logan, Utah.
'30. Stanford, J. S., Agri. College, Logan, Utah. *Siphonaptera.*
'30. Stanley, W. W., Agri. Exp. Sta., Knoxville, Tenn. *Phalaenidae.*
'17. Stearns, Louis A., Agri. Exp. Sta., Newark, Del. *Cercopidae, Cicadellidae.*
'35. Stehr, William C., Dept. of Biology, Ohio Univ., Athens, Ohio. *Coccinellidae, Carabidae.*
'38. Steiner, Harold M., Box 123, Arendtsville, Pa. *Fruit Insects.*
'27. Steiner, L. F., 1237 Washington Ave., Vincennes, Indiana. *Fruit Insects.*
'29. Steinweden, John B., Bur. Nursery Service, State Dept. Agri., Sacramento, Calif. *Coccidae, Thysanoptera.*
'31. Stewart, M. A., Div. of Ent. & Parasitology, Univ. of Calif., Davis, Calif. *Siphonaptera.*
'15. Stiles, Chas. F., Box 29, Stillwater, Okla.
'38. Stitt, Loyd L., Box 273, Tempe, Arizona. *Alfalfa Insects.*
'27. Stone, Alan, Bureau Entomology and Plant Quar., Washington, D. C. *Diptera, Tabanidae.*
'36. Stone, Philip C., Dept. of Entomology, Univ. of Missouri, Columbia, Mo. *Ixodidae.*

'28. Stone, Wm. E., Laboratorio Entomologica, Calzada, Mexico, Tacuba 295, Colonia Anahuac, Mexico, D. F., Mexico.
'30. Strand, A. L., State College, Bozeman, Mont. *Physiology.*
'12. Strickland, E. H., Univ. Alberta, Edmonton, Alberta, Canada. *Elateridae.*
'34. Strom, Lawrence G., 604 A. South 28th St., Milwaukee, Wis. *Aphididae.*
'33. Strong, Lee A., Bureau of Entomology, U. S. Dept. Agri., Washington, D. C.
'31. Summerour, A. R., Box 90, Lucedale, Miss.
'08. Summers, John N., 20 Sanderson St., Greenfield, Mass. *Coccidae.*
'37. Swartzwelder, J. Clyde, Louisiana State Univ., Med. Center, New Orleans, La. *Ixodidae.*
'23. Sweetman, Harvey L., State College, Amherst, Mass. *Ecology.*
'20. SWEZEY, OTTO H., 248 Lanihuli Drive, Honolulu, Hawaii. (F. '30). *Delphacidae.*

'37. Talbot, Mary, Lindenwood College, St. Charles, Missouri. *Formicidae.*
'36. Tanner, M. C., 2907 Lincoln Ave., Ogden, Utah. *Plecoptera.*
'27. Tanner, Vasco M., Brigham Young Univ., Provo, Utah. *Tenebrionidae, Carabidae.*
Ch. Tanquary, M. C., Univ. Farm, St. Paul, Minn. *Apiculture.*
'40. Tarshis, Irvin, 3906 N. E. Hoyt St., Portland, Ore.
'31. Tate, H. D., Dept. Ent., College of Agr., Lincoln, Nebraska. *Ixodidae.*
'36. *Tauber, Oscar E., Zool. Dept., Iowa State College, Ames, Iowa. *Physiology.*
'22. Taylor, Leland H., Dept. Botany & Zool., W. Va. Univ., Morgantown, W. Va. *Bees, Wasps.*
'29. Taylor, R. L., P. O. Box 453, Williamsburg, Va. *Parasitic Hymenoptera.*
'34. Telford, Horace S., Dept. Ent., State College, Fargo, N. D. *Syrphidae.*
'21. Thomas, Chas. A., 120 S. Broad St., Kennett Square, Chester County, Pa. *Elateridae, Scarabaeidae.*
'32. Thomas, Edward S., Ohio State Museum, Ohio State Univ., Columbus, Ohio. *Orthoptera.*
'15. Thomas, F. L., College Station, Texas. *Cotton Insects.*
'37. Thomas, Henry D., Dept. of Ent., Univ. of Kansas, Lawrence, Kansas. *Aquatic Hemiptera.*
'36. Thompson, Geo. A., Jr., Box 102, Florala, Alabama.
'39. Thompson, W. L., Citrus Exp. Station, Lake Alfred, Fla. *Citrus Insects.*
'22. Tietz, Harrison M., Dept. Zool., Pa. St. College, State College, Pa. *Noctuidae.*
'11. TIMBERLAKE, P. H., Citrus Exp. Sta., Riverside, Calif. (F. '38). *Encyrtidae.*
'34. Ting, Peter C., State Agri. Bldg., San Francisco, Calif. *Rhynchophora.*
'23. Tissot, A. N., Agri. Exp. Sta., Gainesville, Fla. *Aphididae.*
'26. Todd, F. E., University Farm, Davis, Calif. *Apiculture.*
'36. du Toit, Rene Michel, Onderstepoort, Pretoria, Transvaal, South Africa. *Diptera, Ixodidae.*
'33. Tongyai, M. R. Chakratong, Department of Agriculture, Bangkok, Siam. *Buprestidae.*
'29. Tosawa, Nobuyoshi, Kotoen, Mukogun, Hiogoken, Japan. *Hymenoptera*
'33. Townes, Henry K., Jr., Dept. Ent., Cornell Univ., Ithaca, N. Y. *Ichneumonidae, Chironomus.*
'28. Townsend, Lee H., Dept. Ent., Univ. of Kentucky, Lexington, Ky. *Neuroptera.*
'36. Trager, Wm., Rockefeller Institute, Princeton, N. J. *Insect Nutrition.*
'39. Traub, Robert, Dept. of Ent., Univ. of Illinois, Urbana, Ill. *Siphonaptera.*
'30. TRAVER, (MISS) JAY R., Fernald Hall, Mass. State College, Amherst, Mass. (F. '35). *Ephemeridae.*
'30. Travis, Bernard V., Box 655, New Smyrna Beach, Fla. *Phyllophaga, Formicidae.*
'39. Trembley, Helen L., Bur. Ent. & Pl. Quar., Washington, D. C.
'34. Trippel, A. W., Indiana Dept. of Conservation, Box 408, Auburn, Indiana. *Chrysomelidae.*
'29. Tsou, Y. H., College of Agri., National Central Univ., Nanking, China.
'38. Tuck, Joseph B., Dept. of Entomology, Kansas State College, Manhattan, Kans. *Orthoptera.*

'28. Tulloch, Geo. S., Dept. of Biology, Brooklyn College, Brooklyn, N. Y. *Morphology.*
'08. Turner, Wm. F., 310 Woodward Ave., Chattanooga, Tenn.
'29. Tuthill, L. D., Dept. of Ent., Iowa State College, Ames, Ia. *Psyllidae, Fulgoridae.*

'39. Uchida, T., Entomological Institute, Hokkaido Imp. Univ., Sapporo, Japan. *Ichneumonidae.*
'20. Uichanco, L. B., Agri. College, Laguna, P. I. *Hemiptera.*
'32. Usinger, Robert L., Div. of Ent. & Parasitology, Univ. of Calif., College of Agri., Davis, Calif. *Heteroptera, except Corixidae.*

'22. Vance, Arlo M., 1920 Parkwood Ave., Toledo, Ohio. *Ecology.*
Ch. Van Dine, D. L., 2737 Devonshire Place, N. W., Washington, D. C. *Fruit Insects.*
Ch. VAN DUZEE, E. P., Calif. Acad. Sciences, Golden Gate Park, San Francisco, Calif. (F. '12). *Hemiptera.*
Ch. VAN DYKE, E. C., Dept. of Entomology, California Acad. Sci., Golden Gate Park, San Francisco, Calif. (F. '17). *Coleoptera.*
'39. Vazquez, Leonila (Miss), Instituto de Biologia, Casa del Lago, Chapultepec D. F., Mexico. *Psychidae.*
'37. Viado, Getulio B., 2184 Lincoln Way, Ames, Iowa.

'15. Wade, J. S., Bureau Entomology, Washington, D. C. (F. '37). *Coleoptera.*
'21. WADLEY, F. M., 8413 Grove St., Silver Spring, Md. (F. '39). *Aphididae.*
'18. Wainwright, C. J., 172 Hamstead Rd., Handsworth, Birmingham, England. *Tachinidae.*
'22. Walkden, Herbert H., 1204 Fremont St., Manhattan, Kansas. *Noctuidae.*
'10. WALKER, E. M., Dept. Biol., Univ. Toronto, Toronto, Ontario, Canada. (F. '14). *Odonata, Orthoptera.*
'30. Walker, Harry G., Va. Truck Exp. Sta., P. O. Box 267, Norfolk, Va. *Economic Entomology.*
'38. Wallace, George E., Dept. Ent., Carnegie Museum, Pittsburgh, Pa. *Chalcididae.*
'23. Wallace, Hugh E., 210 Santa Rita, Modesto, Calif.
'32. Walley, G. Stuart, Ent. Branch, Ottawa, Ontario, Canada. *Hymenoptera, Hemiptera.*
'37. Walter, E. V., Box 495, Lafayette, Indiana. *Economic Entomology.*
'17. WALTON, WM. R., Bureau Entomology, Washington, D. C. (F. '37). *Diptera.*
'36. Wardle, Robert A., Dept. of Zool., Univ. of Manitoba, Winnipeg, Manitoba, Canada.
'13. WATSON, J. R., Agri. Exp. Station, Univ. Fla., Gainesville, Fla. (F. '39). *Thysanoptera.*
'25. Watson, S. A., 321 So. Washington Ave., Whittier, Calif. *Miridae, Hemiptera.*
'16. Webber, Ray T., 8 Whippany Road, Morristown, N. J. *Tachinidae.*
'34. Weber, Neal A., Dept. of Biology, University Station, Grand Forks, N. D. *Formicidae.*
Ch. WEBSTER, R. L., Agri. Exp. Sta., Pullman, Washington. (F. '32).
Ch. WEED, CLARENCE M., 854 Andover St., Lowell, Mass. (F. '24).
'18. Wehrle, L. P., 1130 East Helen St., Tucson, Arizona. *Coccidae, Aphididae.*
'17. Weigel, C. A., Bureau Ent., and Plant Quarantine, Beltsville, Md. *Greenhouse Insects.*
'39. Weinman, Carl J., 308 N. State St., Champaign, Ill. *Insecticides.*
'13. WEISS, HARRY B., 19 N. Seventh Ave., New Brunswick, N. J. (F. '37). *Ecology.*
'12. WELCH, P. S., Dept. Zool., University Mich., Ann Arbor, Mich. (F. '20). *Aquatic Insects.*
'07. Weld, Lewis H., East Falls Church, Virginia. *Cynipidae.*
'21. Wellhouse, Walter H., Dept. Ent., Iowa St. College, Ames, Iowa.
'36. Wells, R. W., P. O. Box 208, Dallas, Texas. *Gasterophilus, Hypoderma.*
'39. Wenzel, Rupert L., 640 Belden Ave., Chicago, Ill. *Histeridae.*

'36. West, A. S., Jr., Dept. of Forest Entomology, University of New Brunswick, Fredericton, New Brunswick, Canada. *Forest Insects.*
'39. Whall, Harry H., Mt. Hope Cemetery, Jackson Ave., Hastings-on-Hudson, N. Y.
'18. Whedon, A. D., 1145 Third St., N., Fargo, North Dakota. *Odonata.*
'22. Wheeler, Geo. C., Univ. Station, Grand Forks, N. Dakota. *Formicidae, Eucharidae.*
'25. Whelan, Don B., College Agri., Univ. Nebr., Lincoln, Nebr. *Noctuidae.*
'32. Whitcomb, W. D., 240 Beaver St., Mass. St. College Exp. Sta., Waltham, Mass.
'29. Wilbur, D. A., K. S. C., Manhattan, Kansas. *Homoptera, Cicadellidae.*
'24. Wilcox, Joseph, P. O. Box 287, Alhambra, Calif. *Asilidae.*
'35. Wild, William, 249 Walnut St., East Aurora, N. Y. *Microlepidoptera.*
'21. Wiley, Grace O., 6441 Long Beach Boulevard, Long Beach, Calif. *Aquatic and Semi-aquatic Hemiptera.*
'32. Wilford, B. H., 223 Federal Bldg., Asheville, N. C. *Forest Insects.*
'36. Wilkes, A., Dept. of Biology, Univ. of Toronto, Toronto, Ontario, Canada.
'29. Will, Homer C., Juniata College, Huntington, Pa. *Tenthredinoidea.*
'38. Willemse, C., Eygelshoven, Z. L., Holland. *Orthoptera.*
'14. WILLIAMS, C. B., Rothamsted Exp. Station, Harpenden, Herts, England. (F. '30). *Migrations of Insects.*
'38. Williams, J. L., Box 90, Lincoln Univ., Pa. *Lepidoptera.*
'30. Williams, Inez W., 58 Waldo St., Brockton, Mass. *Morphology.*
'38. Willis, Harold R., Dept. Ent., Montana State College, Bozeman, Montana. *Orthoptera.*
'23. Willis, Warren J., Rm. 407, 30 E. Forty-second St., New York, N. Y. *Aquatic Insects.*
'23. Wilson, C. C., P. O. Box 1857, Sacramento, Calif. *Orthoptera.*
'39. Wilson, Charles S., Bur. Ent. & Pl. Quar., Nat'l Research Center, Beltsville, Md.
'33. Wilson, Edward H., Denmark, Maine.
'25. Wilson, F. H., Dept. Zool., Tulane Univ., New Orleans, La. *Mallophaga.*
Ch. Wilson, Harley F., Dept. Econ. Ent., King Hall, Univ. of Wisconsin, Madison, Wis. *Aphididae.*
'30. Wilson, John W., Everglades Exp. Station, Belle Glade, Fla. *Economic Entomology.*
'28. Windsor, Margaret, 772 Santa Ynez, Stanford University, Calif. *Stratiomyiidae.*
'37. Wing, Merle W., 35 Bradbury St., Old Town, Maine. *Formicidae.*
Ch. *Wirtner, M., 741 Railroad St., Johnstown, Pa. *Hemiptera.*
'27. Wisecup, C. B., Bureau of Ent. & Plant Quar., Sanford, Fla. *Insecticides.*
Ch. WOGLUM, R. S., Box 5030 Metropolitan Station, Los Angeles, Calif. (F. '39).
'31. Woke, P. A., Bur. of Ent. and Plant Quar., National Agri. Research Center, Beltsville, Md. *Culicidae.*
'34. Wolfenbarger, D. Otis, 266 Glenwood Ave., Bloomfield, N. J. *Economic Entomology.*
'14. Wood, W. B., 4017 Illinois Ave., N. W., Washington, D. C.
'37. Woodbury, Elton N., Dept. Ent., Apicultural Exp. Stat. Annex, Lafayette, Ind. *Insecticides.*
'25. WOODRUFF, L. C., Dept. Ent. Univ. of Kansas, Lawrence, Kans. (F. '35). *Insect Physiology.*
'13. Woods, W. C., Kent School, Kent, Conn. *Chrysomelidae.*
'30. Woodside, A. M., 916 N. Augusta St., Staunton, Va. *Coccidae.*
'17. WOODWORTH, CHAS. W., 2237 Carlton St., Berkeley, Calif. (H. F. '39).
'34. Wormser, Walter Siegfried, 4716 Ingleside, Chicago, Ill.
'22. Worthley, H. N., 501 E. Hamilton Ave., State College, Pa. *Insecticides.*
'28. Wray, David L., Jr., Dept. of Agriculture, Raleigh, N. C. *Collembola.*
'39. Wright, Mike, Dept. Zool. & Ent., Ohio State Univ., Columbus, Ohio. *Odonata.*

'31. YEAGER, J. F., Beltsville Center, Beltsville, Md. (F. '37). *Physiology.*
'35. Yen, Chia-Hsien, Kwangsi Agri. Exp. Stat., Liuchow, Kwangsi, China. *Medical Entomology.*

'28. Young, Hiram C., Box 132, Florala, Alabama. *Cotton Insects.*

'21. Zerny, Hans, Wien I, Burgring 7, Austria. *Heterocera.*
'07. ZETEK, JAMES, Drawer C, Balboa, Canal Zone. (F. '39). *Trypetidae.*
'38. Zimmern, Alfred, 5007 Lindsley Ave., Dallas, Texas. *Isoptera.*

Total Membership, 969. Fellows, 176. Honorary Fellows, 9.
It is interesting to note that there are 77 charter members and 31 life members.